FREEWAVE

MM2-M13 Serial Radios

MM2-M13-C	MM2-M13-C-SR
MM2-M13-LV-C	MM2-M13-LV-T
MM2-M13-T	MM2-M13-T-DEVKIT

Covering Firmware 7.79

User & Reference Manual

Part Number: LUM0021AA
Revision: Mar-2018

Safety Information

The products described in this manual can fail in a variety of modes due to misuse, age, or malfunction. Systems with these products must be designed to prevent personal injury and property damage during product operation and in the event of product failure.

Warning! Do not remove or insert cables while the circuit is live unless the area is known to be free of ignition concentrations of flammable gasses or vapors.

FreeWave Technologies, Inc. warrants the FreeWave® MM2-M13 Serial Radio (Product) that you have purchased against defects in materials and manufacturing for a period of two years from the date of shipment, depending on model number. In the event of a Product failure due to materials or workmanship, FreeWave will, at its discretion, repair or replace the Product. For evaluation of Warranty coverage, return the Product to FreeWave upon receiving a Return Material Authorization (RMA). The replacement product will remain under warranty for 90 days or the remainder of the original product warranty period, whichever is longer.

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2. If Product is used outside of FreeWave specifications as stated in the Product's data sheet.
3. If Product has been modified, repaired, or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing.

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Preface

Contact FreeWave Technical Support

For up-to-date troubleshooting information, check the **Support** page at www.freewave.com.

FreeWave provides technical support Monday through Friday, 8:00 AM to 5:00 PM Mountain Time (GMT -7).

- Call toll-free at 1.866.923.6168.
- In Colorado, call 303.381.9200.
- Contact us through e-mail at moreinfo@freewave.com.

Document Styles

This document uses these styles:

- Parameter setting text appears as: **[Page=radioSettings]**
- File names appear as: **configuration.cfg**.
- File paths appear as: **C:\Program Files (x86)\FreeWave Technologies**.
- User-entered text appears as: **xxxxxxxxx**.

Caution: Indicates a situation that **MAY** cause damage to personnel, the radio, data, or network.

Example: Provides example information of the related text.

FREEWAVE Recommends: Identifies FreeWave recommendation information.

Important!: Provides crucial information relevant to the text or procedure.

Note: Emphasis of specific information relevant to the text or procedure.

Provides time saving or informative suggestions about using the product.

Warning! Indicates a situation that **WILL** cause damage to personnel, the radio, data, or network.

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Parameter Preference

The **Parameter Preference** table describes the available parameters.

<Parameter Name>	
Setting	**Description**
Default Setting:	The factory default setting for the parameter.
Options:	The options the parameter can be set to.
Terminal Menu:	The menu path and field name to access the parameter using the terminal menus available through the serial port.
Description:	A description of what the parameter is and how it applies to the radio in the network.

1. Overview

FreeWave serial radios are DCE (Data Communications Equipment) radios that operate in virtually any environment where data communications occur. The radios act as data transmission devices, duplicating data in either Point-to-Point or Point-To-Multipoint mode.

This document includes:

- A basic introduction to the radio and how to determine the mode you want to run it in.
- Examples of how FreeWave radios can exist in a network with other radios.
- How to access the setup parameters available on the radio.
- Basic radio programming and setup information that applies to all network types.
- Considerations and quick starts for network design, including charts of LED displays.
- Details about defining a Multipoint network including the use of subnet IDs to route information through the network.
- Steps to view statistics about a radio's performance.
- Pinouts and mechanical drawings.

2. Equipment

2.1. Included Equipment

This is the equipment included with the MM2-M13 Serial Radio device:

Included Equipment	
Qty	**Description**
1	MM2-M13 Serial Radio

2.1.1. User-supplied Equipment

- DC power source
- Serial and power cable

2.2. Finding the Product Serial Number

Each FreeWave radio is assigned a unique serial number. When contacting FreeWave Technical Support, this serial number is asked for from the radio you are calling about.

The serial number is three digits, followed by a hyphen and four digits (e.g., 111-1111) and is printed on the FreeWave label on the radio.

3. Installation

3.1. Power Setup

Connect the MM2-M13 Serial Radio to a positive power supply with +8.0 to +30.0 VDC, typically +12.0 VDC.

- The MM2-M13 Serial Radio is approved to operate with a positive power supply / input voltage range of +8.0 to +30.0 VDC (+5 VDC LV models only).
- See the Technical Specifications (on page 108) for additional information.

FREEWAVE Recommends: For guaranteed performance, use between +8.0 to +30.0 VDC to power the radio.
A dedicated power supply line is preferred.
The power supply used MUST provide more current than the amount of current drain listed in the specifications for the product and voltage.

Warning! If the power supply line runs outside the enclosure, use electrostatic discharge (ESD) protectors to protect the radio from electric shock and transient voltage suppressors (TVS) to protect from an over-voltage situation.

3.2. Connections and Installation

Figure 1: MM2-M13 Serial Radio Connections

3.2.1. Radio Setup Mode

- To read the current settings from or to program a radio, the radio must be in **Setup** mode.
  - When a radio is in **Setup** mode, all three LEDs appear solid green .

OEM boards may also enter **Setup** when Pin 2 on the 14-pin connector is grounded or when using a break command.

Note: For **Setup** mode troubleshooting information, see Troubleshooting (on page 96).

3.2.2. Tera Term Activation

Note: This procedure is for a MM2-M13 Serial Radio interfaced to a computer.
If interfaced to a device other than a computer, some of these procedure steps may not be used.

Note: This procedure provides a Tera Term terminal connection to the MM2-M13 Serial Radio CLI.
Other terminal emulators (e.g., HyperTerminal, PuTTY) may be used.
The images in this procedure are for Windows® 7 and/or Firefox®.
The dialog boxes and windows appear differently on each computer.

1. On the computer connected to the MM2-M13 Serial Radio, open a terminal program (e.g., Tera Term http://ttssh2.osdn.jp/).
2. In Tera Term, on the **File** menu, select **New Connection**.

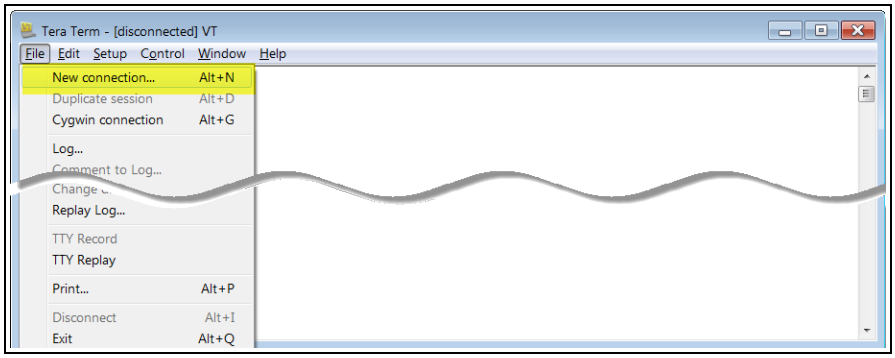


Figure 2: File menu > New Connection

The **Tera Term New Connection** dialog box opens.

3. Click the **Port** list box arrow and select the COM port the MM2-M13 Serial Radio device is connected to.

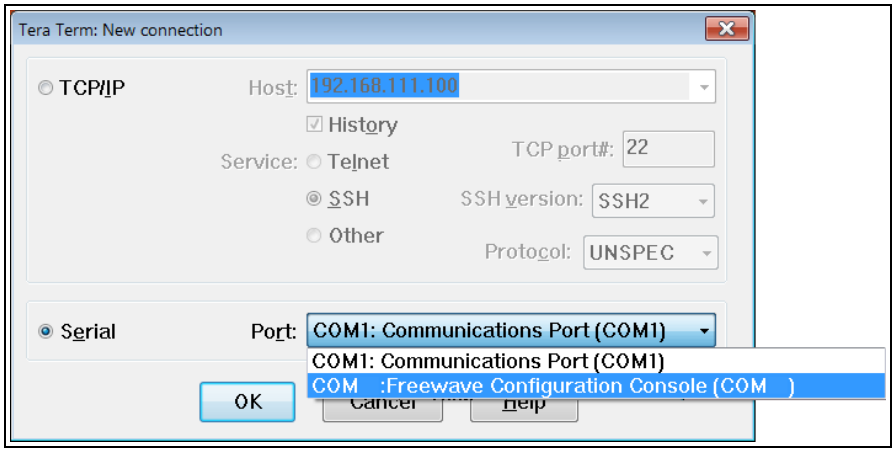


Figure 3: Select the COM port

> **Important!**: The **Port** assignment varies from computer to computer.

4. Click **OK** to save the changes and close the dialog box.
   The Tera Term window shows the connected COM port and Baud rate in the title bar of the window.
5. In the Tera Term window, click the **Setup** menu and select **Serial Port**.

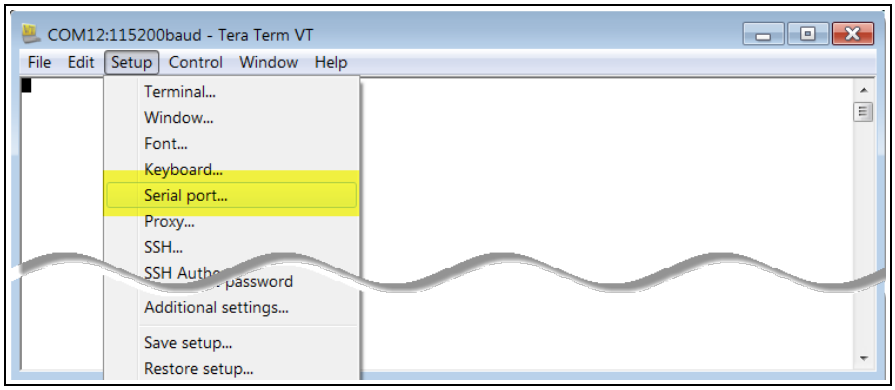


Figure 4: Serial menu > Setup Port

The **Tera Term: Serial Port Setup** dialog box opens with the default MM2-M13 Serial Radio settings.

6. Verify, and change if required, the Tera Term serial port settings (except the **Port** setting) of the connected MM2-M13 Serial Radio so the settings are the same as the defaults shown in Figure 5.

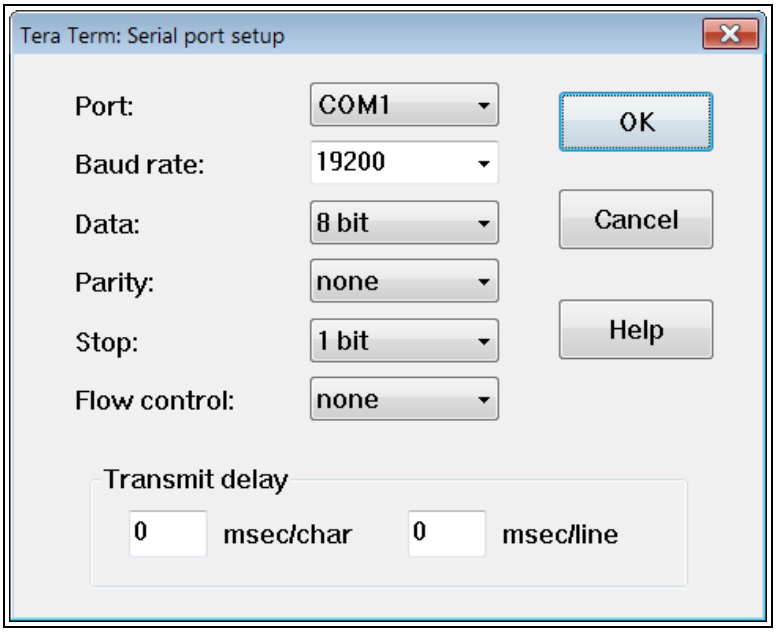


Figure 5: Tera Term: Serial Port Setup dialog box with Default Settings

7. Verify the COM port settings are:
   Baud Rate: 19200
   Data: 8 bit
   Parity: none
   Stop: 1 bit
8. Click **OK** to save the changes and close the dialog box.
9. 9. Place the radio in **Setup** mode.
   When a radio is in **Setup** mode, all three LEDs appear solid green .

   OEM boards may also enter **Setup** when Pin 2 on the 14-pin connector is grounded or when using a break command.

   The Tera Term window refreshes showing the MM2-M13 Serial Radio default Menu Options. (Figure 6)

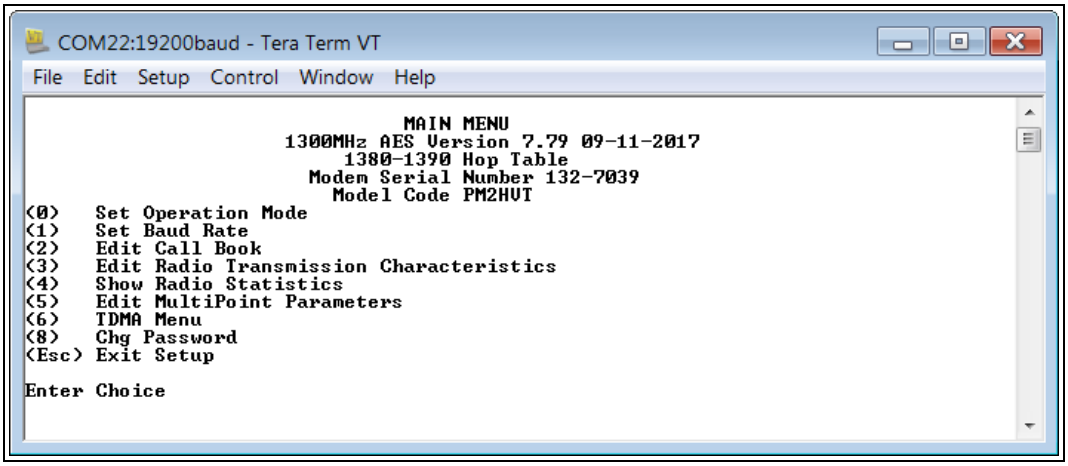


Figure 6: The MM2-M13 Serial Radio Default Menu Options

10. Continue with: Upgrading Serial Firmware Using a Direct Connection (on page 18)

3.3. Choosing a Location for the Radio

When embedding a radio, proper shielding form other electronics and radiated signals should be accounted for to ensure that they do not interfere with the performance of the radio or that the radio does not interfere with the performance of the other electronic devices.

4. Upgrading Serial Firmware Using a Direct Connection

This is a firmware upgrade with a direct connection using the firmware executable file (**.exe**).

Note: Contact FreeWave Technical Support (on page 7) to get the latest firmware upgrade file.

- Firmware update files are also available from FreeWave Technical Support.
- For information about upgrading firmware over the air, see Application Note #5440 (available at http://support.freewave.com/).
  - Registration is required to use this login.

FREEWAVE Recommends: Use USB-to-serial cables that include the FTDI Chip Set to shorten the upgrade time.
This inclusion is listed on the cable's packaging.
For more information, see the Application Note #5471, **Optimizing Firmware Upgrade Speed While Using a USB-Serial Adaptor** available at http://support.freewave.com/.
Registration is required to use this login.

Procedure

Important!: Prior to starting the installation process, verify the **Diagnostics** parameter in the MultiPoint parameters menu is set to **0**.

1. Contact FreeWave Technical Support (on page 7) to get the latest firmware upgrade file.
2. With the radio connected to the computer, double-click the **.exe** file to launch the upload file.

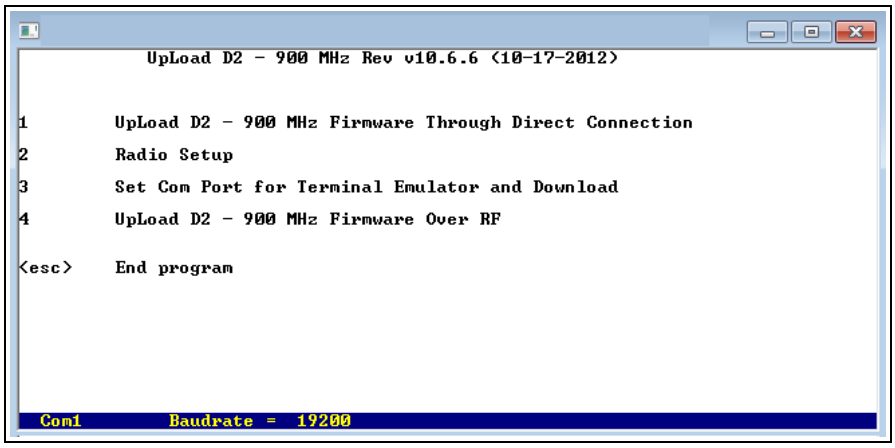


Figure 7: Upload window

3. Verify the COM port settings match the COM port the radio is connected to.

Important!: This program does not work with COM port numbers higher than 2.

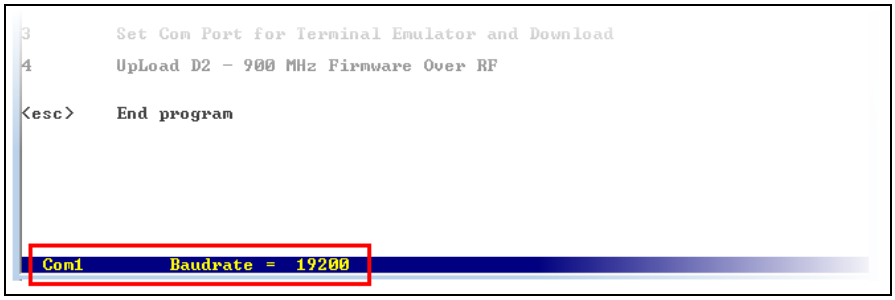


Figure 8: COM port settings

Important!: The baud rate must be set to **19200**.

Note: If the settings do not match, press **3** in the utility, update the settings, and return to the main menu.

4. Type **1** to begin the upgrade process.
5. If the radio is connected to the computer using a **diagnostics cable**, enter **Y** at the **Enter Y for Diag Port** prompt and press <Enter>.
   If the radio is connected to the computer using a **data cable**, enter **N** and press <Enter>.

6. When all three LEDs on the radio are solid green ( ), at the **Radio in Setup** prompt, type **Y** and press <Enter>.

> **Important!**: If all three LEDs are NOT solid green, the radio is NOT in **Setup** mode.
> Do one of the following to enter Setup mode:
> **Enclosed models**: press the Setup button on the back of the device.
> **Board-level models** using a data cable, press the Setup button on the cable.

7. At the **High Speed Download** prompt,
   Type **Y** if using the Diagnostic port or
   Type **N** if fusing the Data port and press <Enter>.

   The upgrade process starts.

   If the process pauses before it is complete, press <Enter> to restart the process.

   When the utility shows the Program Time, the process is complete.

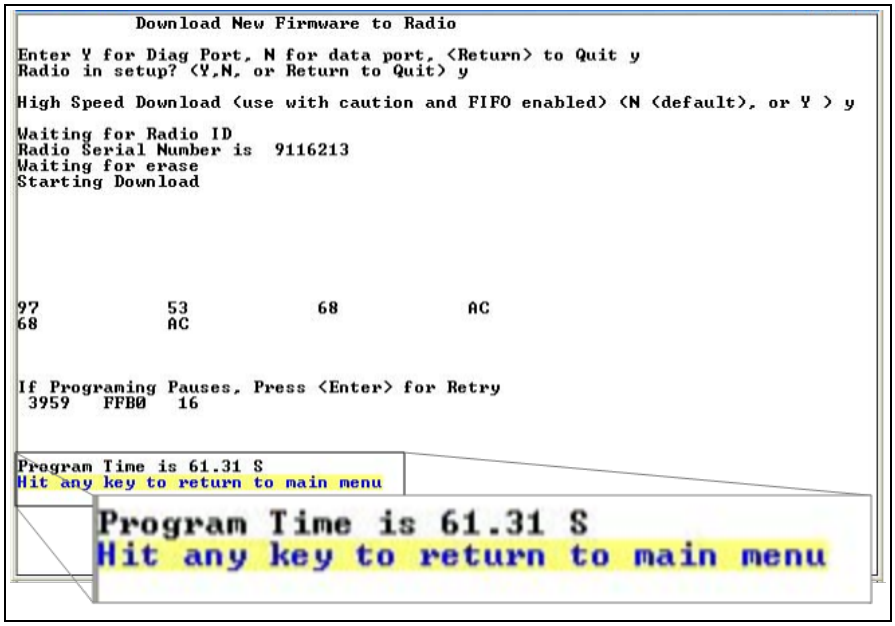


Figure 9: Program Time

8. Press any key to return the main menu.
9. At the main menu, type **2** and place the radio in **Setup** mode.
   The new firmware version number appears at the top of the **Setup** main menu.
10. Type **Q** to return to the utility's main menu.
    Press <Esc> to exit.

5. Basic Radio Programming and Setup

When the network is setup, either as a Point-to-MultiPoint or a Point-to-Point network, the process for setting up and programming a radio is the same. This section describes the aspects of programming and setting up a radio.

5.1. Choosing Point-to-Point or Point-to-Multipoint Operation

5.1.1. Point-to-Point Network

A Point-to-Point network is best when the network has one Master and one Slave radio.

- A maximum of four Repeaters can be added to extend the reach of the network.
- All packets are acknowledged, whether sent from the Master to the Slave or from the Slave to the Master.
- Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.

5.1.2. Point-to-Multipoint Network

In a Point-to-Multipoint network (also referred to as Multipoint network) the Master radio is able to simultaneously communicate with numerous Slave radios.

- In its simplest form, a Multipoint network functions with the Master broadcasting its messages to all Slave radios.
  - The number of times outbound packets from the Master or Repeater to the Slave or other Repeaters are sent is determined by the user.
  - The receiving radio, Slave or Repeater, accepts the first packet received that passes the 32-bit CRC.
  - Packets are not acknowledged by the receiving radio, Slave or Repeater.
- When granted by the Master, the Slave radios respond to the Master when given data by the device connected to the Data port.
  - All packets sent are acknowledged or retransmitted until they are acknowledged.
  - The number of times a packet is sent to the Master is determined by the user.
- The network can be extended with as many Repeaters as is required.
- Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.

Traditionally, a Multipoint network is used where data is collected from many devices and reported back to one central site. The architecture of this network is different from Point-to-Point applications. These parameters influence the number of radios that can exist in a Multipoint network:

- **Data Block Size**. The longer the data blocks, the fewer number of deployed Slave radios can exist in the network.
- **Baud Rate**. The data rate between the radio and the device to which it is connected could limit the amount of data and the number of radios that can exist in a network.
  - **Contention**: The amount of contention between Slave radios. Polled Slave radios versus vs. timed Slave radios.
- **Repeaters**. Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.

Example: If the network polls once a day to retrieve sparse data, several hundred Slave radios could be configured to a single Master.
However, if each Slave transmits larger amounts of data or data more frequently, fewer Slave radios can link to the Master while receiving the same network performance. When larger amounts of data are sent more frequently, the overall network bandwidth is closer to capacity with fewer Slave radios.

5.1.3. Examples of Data Communication Links

FreeWave radios versatility allows data communication links to be established using a variety of different configurations.

- Point-to-Point Link (on page 23)
- Point-to-Point Link with Repeater (on page 23)
- Two Repeaters between the Master and Slave (on page 24)
- Master Calls Slaves at Different Times (on page 24)
- Standard Point-to-Multipoint Network (on page 25)
- Point-to-Multipoint Network with a Multipoint Slave/Repeater (on page 26)

Point-to-Point Link

Figure 10 shows the most common and straightforward link, a Master communicating to a Slave in a Point-to-Point link.

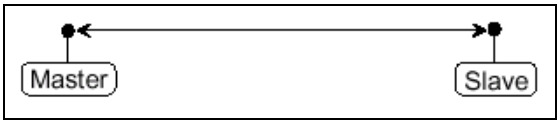


Figure 10: Point-to-Point Link

Point-to-Point Link with Repeater

Figure 11 shows how a link might be set up using a repeater.

- If a Repeater is located on a hilltop or other elevated structure, it can enhance the link from the Master to the Slave.
- In this configuration, it is desirable to use an Omni-directional antenna at the Repeater.
- Yagi antennas may be used at both the Master and Slave radios to increase the range of the link.

Note: Adding Repeaters to a network cuts the data throughput by 50% and **decreases** overall network capacity by 50%.

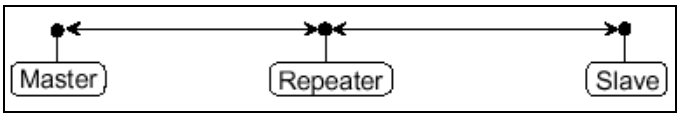


Figure 11: Point-to-Point Link with Repeater

Two Repeaters between the Master and Slave

Figure 12 shows a link with two repeaters between the Master and Slave.

- With two Repeaters more flexibility in getting around obstacles and greater total range is possible.
- In this configuration, it is desirable to use an Omni-directional antenna at the Repeater.
- Yagi antennas may be used at both the Master and Slave radios to increase the range of the link.

Note: When two Repeaters are used, no further degradation in the data throughput of the link is experienced.

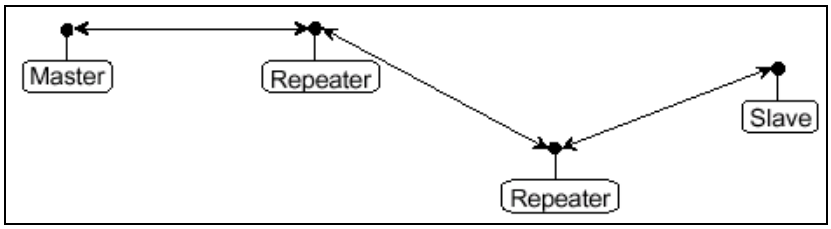


Figure 12: Two Repeaters between the Master and Slave

Master Calls Slaves at Different Times

Figure 13 shows a configuration where a Master routinely calls a number of Slaves at different times.

- The Master is communicating with a radio designated as a Slave/Repeater that is connected to a remote device.
- Since this device is placed in an elevated location, the radio can also be used as a repeater when it is not used as a Slave.
- At any time the Master can call any of the Slaves, establish a connection, and send and receive data.

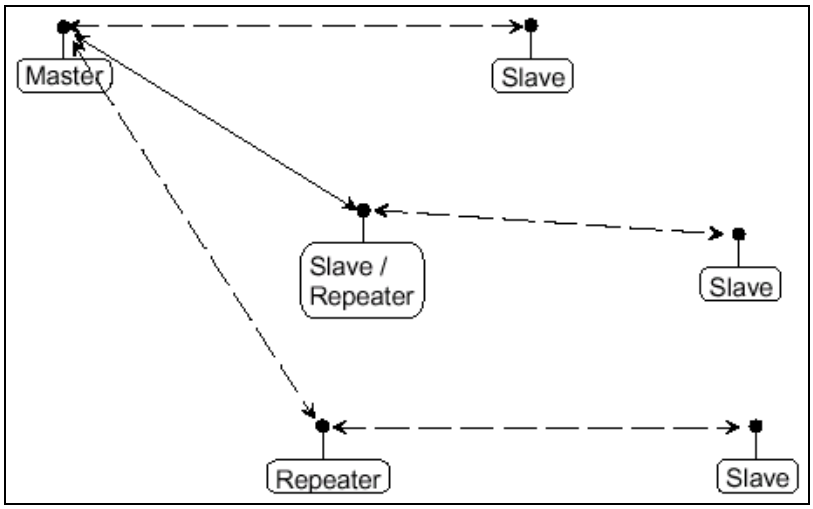


Figure 13: Master Calls Slaves at Different Times

Standard Point-to-Multipoint Network

Figure 14 shows a standard Point-to-Multipoint network.

- From the Master, data is broadcast to all three Slaves, one of which receives it through a Multipoint Repeater.
- The data is sent out of the serial port of each of the three Slaves.

Important!: The end device should be configured to interpret the serial message and act on it if necessary.

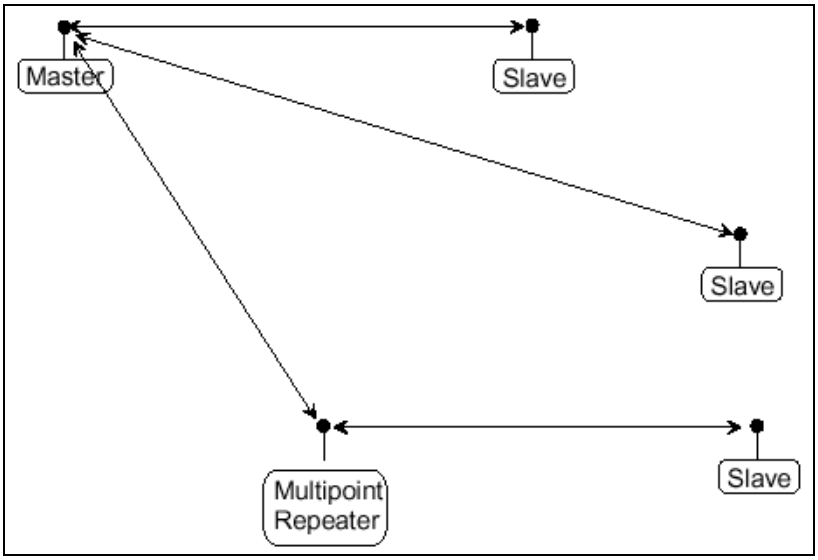


Figure 14: Standard Point-to-Multipoint Network

Point-to-Multipoint Network with a Multipoint Slave/Repeater

Figure 15 shows a Point-to-Multipoint network that uses one of the sites as a Slave/Repeater.

- This network functions in the same manner as a standard Multipoint network with Repeaters.
- However, the number of radios can be reduced with the use of the Multipoint Slave feature.
- The Multipoint Slave allows communication to a device connected locally to the Multipoint Slave's serial port while also acting as a Repeater to pass messages between the Master and a Slave.
- When compared to the Multipoint Repeater, the Multipoint Slave can only pass messages between the Master and the Slave.
  - It is not capable of passing messages to a device locally connected to its serial port.

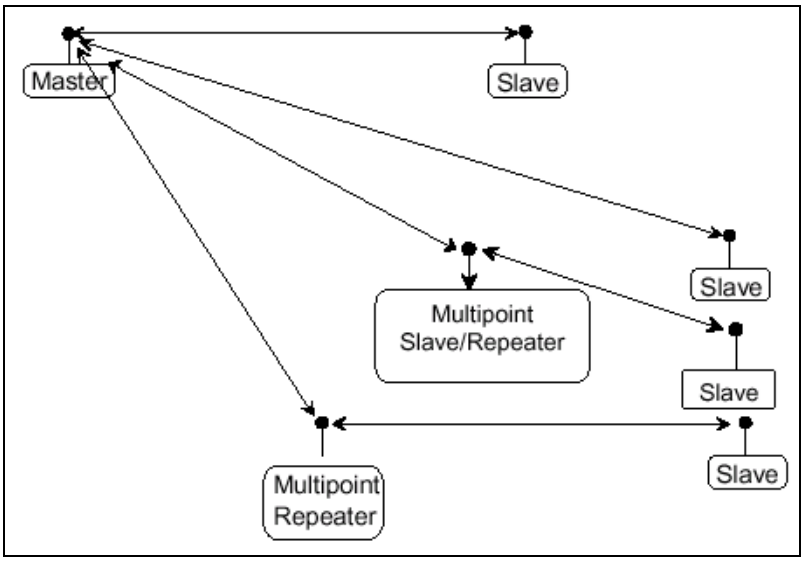


Figure 15: Point-to-Multipoint Network with a Multipoint Slave

Standard TDMA Network

Note: TDMA is an option available for the MM2-M13 Serial Radio.

- A standard TDMA network requires a Master and Slave.
- Dedicated time slots are allocated to the Master and each of the Slaves guaranteeing specific transmission slots.
- Slaves can be configured to communicate directly with other Slave.

5.2. Define the Radio's Role in the Network and the Network Type

On the **Operation Mode** menu, use the **Modem Mode** field to set the **Modem Mode**.

Note: These settings are available in the **Operation Mode** menu in the terminal interface.

The Operation Mode option designates the method FreeWave radios use to communicate with each other. FreeWave radios operate in a Master to Slave configuration. Before the radios can operate together, they must be set up to properly communicate.

In a Point-to-Point configuration, Master or Slave mode may be used on either end of the communication link without performance degradation.

- When setting up the radio, remember that a number of parameters are controlled by the settings in the Master.
- Therefore, deploying the Master on the communications end where it will be easier to access is advised, but not necessary.

Operation Mode	Description
Point-to-Point Master (0)	This mode designates the radio as the Master in Point-to-Point mode. The Master may call any or all Slaves designated in its Call Book. In Point-to-Point mode the Master determines the setting used for most of the transmission characteristics, regardless of the settings in the Slaves and/or Repeaters. The settings NOT determined by the Master are: • Transmit Power • Slave Security • Retry Time Out • Hop Table settings Tip: A quick method of identifying a Master is to power the radio. Prior to establishing a link with a Slave, all three of the LEDs on the Master are solid red.
Point-to-Point Slave (1)	This mode designates the radio as a Slave in Point-to-Point mode. • The Slave communicates with any Master in its Call Book either directly or through a maximum of four Repeaters. • When functioning as a Slave, the **Entry to Call** feature in the radio's Call Book is NOT operational. • Set the **Slave Security** parameter to 1 to bypass the Call Book in the Slave. • For more information, see Slave Security (6) (on page 49).

Operation Mode	Description
Point–to-MultiPoint Master (2)	This mode designates the radio as a Master in MultiPoint mode. • This mode allows one Master radio to communicate simultaneously with numerous Slaves and Repeaters. • A Point-to-MultiPoint Master communicates only with other radios designated as Point-to-MultiPoint Slaves or Point-to-MultiPoint Repeaters.
Point-to-MultiPoint Slave (3)	This mode designates the radio as a Slave in MultiPoint mode. • This mode allows the Slave to communicate with a MultiPoint Master. • The Slave may communicate with its Master through one or more Repeaters.
Point-to-Point Slave/Repeater (4)	This mode designates the radio to act as EITHER a Slave or Repeater, depending on the instructions from the Master. • The radio cannot act as both a Slave and a Repeater at the same time. • True Slave / Repeater functionality is only available in a MultiPoint mode. • Point-to-Point Slave / Repeaters have no security features. • When a radio is designated a Point-to-Point Slave / Repeater, it allows any Master to use it as a Repeater.
Point-to-Point Repeater (5)	FreeWave allows the use of a maximum of four Repeaters in a Point-to-Point communications link, significantly extending the operating range. • When designated as a Repeater, a radio behaves as a pass-through link. • All settings for the Call Book, Baud Rates, and transmission characteristics are disabled. • A Repeater connects with any Master that calls it. • The Repeater must be set up properly in the Master's Call Book.
Point-to-Point Slave/Master Switchable (6)	Mode 6 allows the radio to be controlled entirely through software commands. • A number of key parameters in the FreeWave user interface may be changed either directly using a program such as Windows® Terminal or through the use of script files. • Additionally, when the **Point-to-Point Slave/Master Switchable** option is selected and the radio is not calling a Slave, it functions as a Slave and accepts any appropriate calls from other radios. **Note**: For more information, see Application Note #5476, Mode 6 (available at http://support.freewave.com/).
Point-to-MultiPoint Repeater (7)	This option allows the radio to operate as a Repeater in a MultiPoint network. • As many Repeaters as necessary are allowed in a MultiPoint network. • If the Repeater is to act as a Slave / Repeater, set the **Slave Repeater** parameter in the **MultiPoint Parameters** menu to `Enabled`.

Operation Mode	Description
Ethernet Options (F)	**Note**: This menu is only used for Ethernet radios. Although this menu is included here, it is not used in the MM2-M13 Serial Radio.

5.3. Establishing Communication with Instrumentation and Computers

5.3.1. Baud Rate

The **Baud Rate** menu establishes the communications settings between the radio and the device or computer it is connected to (radio serial port to the device).

Example: A pair of radios may be used in an application to send data from remote process instrumentation to an engineer's computer.
In this use, the **Baud Rate** for the radio on the instrumentation might be set to `9600` and the radio on the polling host might be set to `57,600`.

1. On the **Main Menu**, type `1`.
   The **Set Baud Rate** menu opens.
2. Enter a value between 0 and 9 to set the Baud Rate.

   Note: 0 = Baud Rate of 230 and 9 = 1,200.
   This applies to all types of networks.

Important!: This setting is independent of the **Baud Rate** for any other radios in the network.

5.3.2. Data, Parity

When Data, Parity is selected from the Baud Rate menu, a prompt to enter a value appears.

Data, Parity	
Setting	**Description**
Default Setting:	0 (8, N, 1)
Options:	<table><tr><th>Option</th><th>Data Bits</th><th>Parity</th><th>Stop Bits</th></tr><tr><td>0</td><td>8</td><td>None</td><td>1</td></tr><tr><td>1</td><td>7</td><td>Even</td><td>1</td></tr><tr><td>2</td><td>7</td><td>Odd</td><td>1</td></tr><tr><td>3</td><td>8</td><td>None</td><td>2</td></tr><tr><td>4</td><td>8</td><td>Even</td><td>1</td></tr><tr><td>5</td><td>8</td><td>Odd</td><td>1</td></tr></table>
Terminal Menu:	(1) Set Baud Rate > (A) Data, Parity
Description:	• Six data word length and parity configurations are available for use with FreeWave radios. • The default setting is **8-None-1** and is the most commonly used serial communications protocol.

5.3.3. Flow Control

Flow Control	
Setting	**Description**
Default Setting:	(0) None

Options:	• **(0) None**: No flow control CTS is active and de-asserts when buffering is 98% full.
	  • Can pass XON/XOFF data but does not use it in any way.
	• **(1) RTS**: Uses RTS/CTS (Request to Send/Clear to Send) for flow control.
	• **(2) DTR**: Uses DTR/DSR (Data Terminal Ready/Data Set Ready) for flow control.
	• **(3) DOT**: Half Duplex
	Note: **(3) DOT**: Half Duplex is NOT visible in the menu but is accepted when `3` is entered.
	  • **(3) DOT** causes the Carrier Detect (CD)line to indicate when data is transmitted on the serial port from the radio.
	  • When the radio is NOT sending data to the serial port, CD is de-asserted.
	  • When the radio is sending data to the serial port, CD is asserted and the CD line no longer has any radio link state functionality.
	Note:

Terminal Menu:	(1) Set Baud Rate > (F) FlowControl
Description:	• Specifies the hardware flow control for the data port on the radio. • Flow control is the process of managing the speed at which data is transmitted so as not to overwhelm the device receiving the transmission. **FREEWAVE Recommends**: Use **Flow Control** if using a **Baud Rate** higher than `38,400`.

5.3.4. Modbus RTU

Important!: When using the radio in **Modbus RTU** mode, the Master Packet Repeat (1) (on page 66) MUST match in every radio regardless of whether the network is in Point-to-Point or MultiPoint mode.
The **Modbus RTU** mode must be selected when radios are configured in RS422 or RS485 mode.

Modbus RTU	
Setting	**Description**
Default Setting:	(0) Disabled
Options:	0 to 9
Terminal Menu:	(1) Set Baud Rate > (B) Modbus RTU

Description:	A setting other than 0 in this parameter causes the radio to wait for an amount of time gathering data before sending out the RF link.
	• **0 (Disabled)** - The radio sends data out through its RF link as soon as the data is received into the serial port. This is the default setting.
	• **1** - The radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the RF link.
	  • With a setting of 1, the radio waits for a number of slots equal to two times the **Master Packet Repeat** setting before sending the received data out the RF link.
	  Example: If the **Master Packet Repeat** parameter is set to 3, the radio waits for 6 slots, gathering data up the whole time. At the end of the 6 slots, the radio sends all received data in one "burst." This is the appropriate setting for most Modbus RTU devices.
	• **2 or higher** - The radio waits for a number of slots calculated using this formula:
	(Modbus RTU setting + Master Packet Repeat setting + 1) x 2
	  Example: In a radio where the **Modbus RTU** setting is 2 and the **Master Packet Repeat** setting is 3, the radio waits for (2 + 3 + 1) x 2, or 12 slots.

5.3.5. RS422 / RS485 (Serial Interface)

RS422 / RS485 (Serial Interface)	
Setting	**Description**
Default Setting:	(0) RS232

RS422 / RS485 (Serial Interface)	
Setting	**Description**

Options:	• **(0) RS232**: Also used for TTL.
	• **(1) RS422**:
	  • Modbus RTU (on page 31) must be `Enabled`.
	• **(2) RS485**:
	  • Modbus RTU (on page 31) must be `Enabled`.
	• **(3) DOT**:
	  • Causes the CD line to indicate when data is transmitted on the serial port from the radio.
	  • When the radio is sending data to the serial port, CD is asserted.
	  • When the radio is NOT sending data to the serial port, CD is de-asserted.
	  • The CD line no longer has any radio link state functionality.
	  • Turn Off Delay (on page 34) works as described in all radios.
	  • Turn On Delay (on page 34) works as described on any Slave or Slave/Repeater - it has no functionality on the Master radio.
	Important!: If set to anything other than `0`, the **Setup Port** parameter on the **Baud Rate** tab MUST be set to `Diagnostics Only`.

Terminal Menu:	(1) Set Baud Rate > (C) RS232 / RS485
Description:	Use this option to set the protocol of the data port for connection to an external device. **Important!**: This setting must be `0` in TTL MM2-M13-T and MM2-M13-LV-T board products.

5.3.6. Setup Port

Caution: Do NOT change this setting unless the correct programming cable is available for the new setting.

Setup Port	
Setting	**Description**
Default Setting:	(3) Both

Setup Port	
Setting	**Description**
Options:	• **(1) Main Only**: Programming and reading the radio's setup information is done through the Data port. • **(2) Diagnostics Only**: Programming and reading the radio's setup information is done through the Diagnostic port. • If the **Serial interface** is set to anything other than RS232, then the **Setup Port** must be set to `Diagnostics Only`. • **(3) Both**: Programming and reading the radio's setup information is done through either the Data port or the Diagnostic port.
Terminal Menu:	(1) Set Baud Rate > (D) Setup Port

Description:	Determines which port on the radio, Main or Diagnostics, is used to access the parameter settings in the **Setup** main menu in the terminal interface.
	Press <Shift+U> to activate the **Setup** mode to the Diagnostics port or by temporarily grounding pin 2.
	• The OEM modules use a 2-row, 2 mm female connector.
	• The main Data port:
	  • is the RS232 port.
	  • consists of the Data Rx, Data Tx, Gnd, and handshaking pins.
	• The Diagnostics port consists of the Diag Rx, Diag Tx, and Gnd pins.

5.3.7. Turn Off Delay

Note: The MM2-M13 Serial Radio does NOT use this parameter.

5.3.8. Turn On Delay

Note: The MM2-M13 Serial Radio does NOT use this parameter.

5.3.9. Use Break to Access Setup

Use Break to Access Setup	
Setting	**Description**
Default Setting:	(0) Disabled
Options:	• **(0) - Disabled**: The break command is disabled. • **(1) - Enabled**: The Setup menu is sent at `19,200` bps. • **(2) - Enabled**: The Setup menu is sent at the radio's current **Baud Rate**. • This setting is ONLY available through the terminal interface.
Terminal Menu:	(1) Set Baud Rate > (G) Use break to access setup

Use Break to Access Setup	
Setting	**Description**
Description:	Enables a break command to put the radio into Setup mode over the data port. • To send a break character, the end device must hold the transmit data line in the space voltage level for longer than 1 character time. **Example**: If a character is defined as having 1 start bit, 8 data bits, and 1 stop bit, the character time is 10 bits, thus the transmit data line must be held in the space voltage level for a period of time longer than 10 bits.

5.4. Establishing Communication with Other Radios in the Network

For the radios in the network to communicate successfully, the radios need to communicate with the other available devices. Use one of these options:

- **Network ID**: Used in MultiPoint Networks, the **Network ID** parameter is on the MultiPoint Parameters menu.
  - Each radio in a single network should be assigned the same **Network ID**.
  - A Slave links with the first Master or Repeater that it hears that has a matching **Network ID**.
  - Because the **Network ID** does not use serial numbers, MultiPoint Masters and Repeaters may be replaced without reprogramming all of the Slaves in the network.
  - The **Network ID** function should be used in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.
  - Without having the serial numbers in the Call Book, Slaves may establish communications with different Masters that match the radio's Golden Settings (on page 36), though not at the same time.
    - This is very useful in mobile MultiPoint applications.

  Note: For information about setting the **Network ID** parameter in a MultiPoint Network, see Using the Network ID in Multipoint Networks (on page 56).
- **Call Book**: The Call Book is **required** in Point-to-Point networks.
  - The Call Book stores serial numbers of other radios in the network that are allowed to talk to a radio.
  - Using the Call Book offers both security and flexibility in determining how FreeWave radios communicate with each other.
    - For more information about defining the Call Book in a Point-to-Point network, see Using Call Book in Point-to-Point Networks (on page 81).
    - For more information about defining the Call Book in a Point-to-MultiPoint network, see Using Call Book in Multipoint Networks (on page 57).

5.4.1. Golden Settings

A standard network requires that these parameters are set the same on all radios in the network - FreeWave refers to these as the golden settings.

- Frequency Key in 1.3GHz Radios (on page 37)
- Max Packet Size (1) and Min Packet Size (2) (on page 43)
- Network ID (6) (on page 68)
- RF Data Rate (4) (on page 46)

Radios that contain the same settings in all these parameters can communicate with each other.

Important!: If Call Book is used instead of the **Network ID**, or a Point-to-Point network is running, the appropriate serial numbers MUST be listed in the Call Book for each radio.
If working with parallel Repeaters, the **Frequency Key** setting may differ.

5.5. Setting RF Transmission Characteristics

The Transmission Characteristics parameters are used to change settings that determine how data is sent between radios in the network. Many of these parameters must be maintained throughout the network for proper functionality.

The parameters in the **Transmission Characteristics** menu are for advanced users with a good understanding of the principles of RF transmission.

Note: Most parameters in the **Edit Radio Transmission Characteristics** menu can be left to their default settings when completing basic setup.

- Several settings on a Slave or Repeater radio come from the Master and are set ONLY at the Master.
  - These settings MUST be set on **every** Slave / Repeater:
    - Hop Freq Offset (2) (on page 40)
    - Hop Table Size (1) (on page 40)
    - Hop Table Version (0) (on page 41)
    - Retry Time Out (8) (on page 45)
    - RF Xmit Power (5) (on page 47)
    - Slave Security (6) (on page 49)

Caution: These parameters MUST be set AND they **must be the same** for all radios in the network.

- Frequency Key in 1.3GHz Radios (on page 37)
- Hop Freq Offset (2) (on page 40)
- Hop Table Size (1) (on page 40)
- Hop Table Version (0) (on page 41)
- Max Packet Size (1) and Min Packet Size (2) (on page 43)
- RF Data Rate (4) (on page 46)

5.5.1. Frequency Key in 1.3GHz Radios

Selecting `0` on the **Radio Parameters** menu allows the hopping patterns of the radio to be changed.

- Fifteen choices are available for the **FreqKey** (0-9 and A-E) setting, representing 15 different pseudo-random hop patterns.
- **FreqKey** is used to minimize the interference with other FreeWave radios operating in the area.

  Example: If ten pairs of FreeWave radios are operating on different networks in close proximity to each other, using a different **FreqKey** value reduces the chance that radios will hop to the same frequency at the same time.
  If two networks were to hop to the same frequency, the next hop would be to a different frequency for both networks.
- Adjust the **Max and Min Packet Size** options to gain additional network separation.
- The default value is 5.

Procedure

1. Type `0 Freq Key`.
2. Type any value between 0 and E to select an existing pseudo-random hop pattern.
3. Type `1 Max Packet Size`.
4. Type any value between 0 and 9.
5. Type `2 Min Packet Size`.
6. Type any value between 0 and 9.
7. Type `F` for additional options.
   The **Hop Table Parameters** appear.

   Note: All radios in a network must have identical Hop Table settings to function properly.

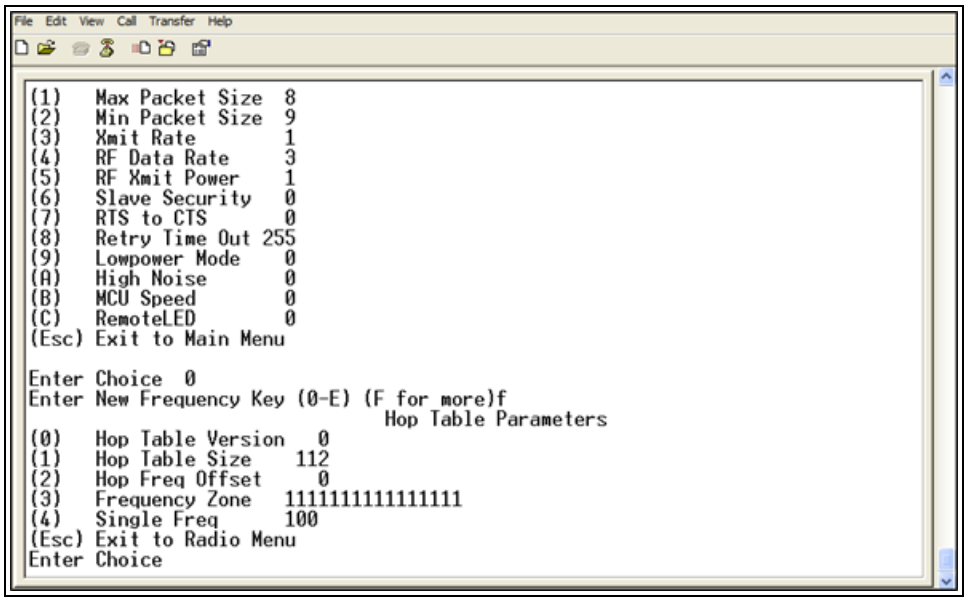


Figure 16: 0 > F > Hop Table Parameters

8. Define additional network differentiation by limiting the number and location of frequencies the radios can hop on in the 1350 – 1390 MHz band.
9. Press <Esc> to return to the Main Menu.

5.5.2. Frequency Zone (3)

Note: **Frequency Zone** entries begin with 1 (LSB) and continue through 16 (MSB).

Frequency Zone (3)	
Setting	**Description**
Default Setting:	1

Frequency Zone (3)	
Setting	**Description**
Options:	

Binary Zone Number (LSB First MSB Last)	Beginning Freq. (MHz)	Ending Freq. (MHz)	Number of Channels
1	1350.1440	1352.6784	12
2	1352.9088	1355.2128	11
3	1355.4432	1357.7472	11
4	1357.9776	1360.2816	11
5	1360.5120	1362.8160	11
6	1363.0464	1365.3504	11
7	1365.5808	1367.8848	11
8	1368.1152	1370.6496	12
9	1370.8800	1373.1840	11
10	1374.4144	1375.7184	11
11	1375.9488	1378.2528	11
12	1378.4832	1380.7872	11
13	1381.0176	1383.3216	11
14	1383.5520	1385.8560	11
15	1386.0864	1388.3904	11
16	1388.6208	1389.7728	6

Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > (F) More > (3) Frequency Zone
Description:	Frequency zoning is used to divide the available band (1.350 GHz – 1.390 GHz) into 16 smaller bands, each consisting of 6, 11, or 12 frequency channels, depending on the frequency zone. • The 16 zones are stored in a Microsoft® Word file, made up of 16 bits numbered 1-16. • These bits, when shown in LSB to MSB, directly represent the zones that the radio operates on from lowest frequency to highest. • A **1** value in the bit sequence instructs the radio to operate within the represented band. • A **0** value instructs the radio to bypass the represented band. **Important!**: This feature should only be used with the Hop Table Version (0) (on page 41).

5.5.3. High Noise (A)

Note: **High Noise** is shown in the menu but is NOT supported in the MM2-M13 Serial Radio.

5.5.4. Hop Freq Offset (2)

The **Hop Freq Offset** setting is used to select a frequency offset of 115.2 kHz or 230.4 kHz, which is higher than the standard frequency selection. Using this option helps to separate radio networks that are located in the same geographic area.

Example: If two networks are operating in the same area with one set to **Hop Freq Offset** = 0 and the other set to **Hop Freq Offset** = 1, the frequencies used in the hopping patterns are separated by 115.2 kHz, even if the hopping patterns are the same.

Hop Freq Offset (2)	
Setting	**Description**
Default Setting:	0
Options:	• 0 - no offset • 1 - 115.2 kHz offset • 2 - 230.4 kHz offset
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > (F) More > (2) Hop Table Offset
Description:	The **Hop Freq Offset (2)** parameter is used to shift the center frequency of all channels by either 115.2 kHz or 230.4 kHz. Regardless of the **FreqKey** used, all radios MUST be set in either Point-to-Point or Point-to-MultiPoint networks: • Hop Table Version (0) (on page 41) • Hop Table Size (1) (on page 40) • Hop Freq Offset (2)

5.5.5. Hop Table Size (1)

Hop Table Size (1)	
Setting	**Description**
Default Setting:	112
Options:	75-112
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > (F) More > (1) Hop Table Size
Description:	The **Hop Table Size** defines how many separate channels are used by a given network.

5.5.6. Hop Table Version (0)

Hop Table Version (0)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	**Selection** / **Band** 0 – 1350 – 1390 MHz 1 – 1350 – 1360 MHz 2 – 1360 – 1370 MHz 3 – 1370 – 1380 MHz 4 – 1380 – 1390 MHz 5 – 1350 – 1370 MHz 6 – 1370 – 1390 MHz
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > (F) More > (0) Hop Table Version
Description:	The **Hop Table Version** option is used to specify the portion of the band the radio can operate in.

5.5.7. Lowpower Mode (9)

Lowpower Mode (9)	
Setting	**Description**
Default Setting:	(0) Disable
Options:	0-31
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (9) Low Power Mode
Description:	The **Lowpower Mode** option allows a Multipoint Slave to consume less power by dimming the radio's LEDs. • When **Lowpower Mode** is set to 2 through 31, the radio sleeps between slots. **Example**: A setting of 2 and the radio sleeps 1 out of 2 slots. A setting of 3 and the radio sleeps 2 out of 3 slots.

This table shows:

- The changes at different **Lowpower Mode** settings.
  - The actual current draw depends on many factors.
- Only a qualitative indication of supply current savings.
  - A low number reduces latency and a high number reduces current consumption.

Current Draw	Setting	Description
More	0	Lowpower, disabled.
	1	• LEDs are dimmed. • Radio remains awake, listening to the Master's transmissions on every slot. • The radio's data port is shut down if the RTS line is de-asserted (low). • In this case, the radio needs to be awakened before it can send data to the Master.
	2	LEDs dimmed, radio sleeps every other slot.
	3	LEDs dimmed, radio sleeps 2 of 3 slots.
Less	4-31	LEDs dimmed, radio sleeps the number of slots corresponding to the setting. **Example**: Using a setting of `31`, the radio sleeps 30 of 31 slots.

Important Notes

- **Lowpower Mode** is used only in Multipoint Slave using serial protocol.
  - Power savings occur only when the Slave is linked.
  - No power savings occur when the Slave is transmitting data.
- **Lowpower Mode** is of little value when a Slave has a constant, high throughput.
  - For **Lowpower Mode** to operate properly, **MCU Speed** must be set to `0` and **RF Data Rate** must be set to `3`.
- Additional power savings are realized when **Number Repeaters** is set to `1`.
- To communicate to a TTL port of a radio that is in **Lowpower Mode**, the RTS line must be held high to wake it up.
  - The radio wakes up within approximately 20 milliseconds of when RTS goes high.
- If the RTS line on the Slave is held high, the radio remains in normal operation regardless of the **Lowpower Mode** setting.
  - Once RTS is dropped, the radio reverts to the **Lowpower Mode**.
- If the radio has the **DTRConnect** option set to `1` or `2` and if the **Lowpower Mode** enabled (set to 1-31), the RTS line on the radio must be asserted for the **DTRConnect** feature to operate properly.
- Disable or terminate the Diagnostic pins to a cable for the **Sleep** current in **Lowpower Mode** to match the specifications.
  - To disable the Diagnostics pins, verify the:
    - **(1) Baud Rate** / **(D) Setup Port** is set to `1, Main Only`.
    - **(5) Multipoint Parameters** / **(B) Diagnostics** is set to `0`, `Off`.

5.5.8. Max Packet Size (1) and Min Packet Size (2)

The **Max and Min Packet Size** settings and the **RF Data Rate** determine the number of bytes in the packets. Throughput can be enhanced when packet sizes are optimized.

- In Point-to-Point mode, the **Max and Min Packet Size** settings do NOT have material impact on throughput unless 115.2 kbps is desired.
- However, this has an impact on latency.

> **Example**: If small amounts of data are sent and large packet sizes are selected, a certain amount of time "wasted" between each packet would be seen.

These three tables provide the information to determine optimum setting values.

- The default settings for **Max Packet Size**, **Min Packet Size**, and **RF Data Rate** are 8, 9, and 2, respectively.

Minimum Packet Size Definition Table

The **Minimum Packet Size Definition** table defines the minimum packet size in bytes by way of charting the **Min Packet Size** setting versus the **RF Data Rate** setting. Using the default settings, the actual minimum packet size, in bytes, is 44.

Minimum Packet Size Definition		
Min Setting	**Min Packet Size RF Data Rate = 2**	**Min Packet Size RF Data Rate = 3**
0	15	8
1	21	12
2	26	16
3	31	20
4	37	24
5	42	28
6	47	32
7	53	36
8	58	40
9	63	44

Maximum Packet Size Definition with RF Date Rate of 2

The **Maximum Packet Size Definition with RF Date Rate of 2** table defines the maximum packet size in bytes by way of charting the **Min Packet Size** setting versus the **Max Packet Size** setting where the **RF Data Rate** is set to 2.

Maximum Packet Size Definition with RF Date Rate of 2										
Min Setting	**Max Setting**									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	15	37	58	79	101	122	143	165	186	207
1	21	42	63	85	106	127	149	170	191	213
2	26	47	69	90	111	133	154	175	197	218
3	31	53	74	95	117	138	159	181	202	223
4	37	58	79	101	122	143	165	186	207	229
5	42	63	85	106	127	149	170	191	213	234
6	47	69	90	111	133	154	175	197	218	239
7	53	74	95	117	138	159	181	202	223	245
8	58	79	101	122	143	165	186	207	229	250
9	63	85	106	127	149	170	191	213	234	255

- Referencing the default settings, the Master transmits a minimum of 63 bytes and can transmit up to 234 bytes on every hop.
- If fewer than 234 bytes are transmitted, the balance less 63, is allocated to the Slave's transmission, plus the quantity in the **Min Packet Size** setting.

Note: Using the default settings, the actual maximum packet size, in bytes, is 234.

Maximum Packet Size Definition with RF Date Rate of 3

The **Maximum Packet Size Definition with RF Date Rate of 3** table defines the maximum packet size in bytes by way of charting the **Min Packet Size** setting versus the **Max Packet Size** setting where the **RF Data Rate** is set to **3**.

Maximum Packet Size Definition with RF Date Rate of 3										
Min Setting	**Max Setting**									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	8	24	40	56	72	88	104	120	136	152
1	12	28	44	60	76	92	108	124	140	156
2	16	32	48	64	80	96	112	128	144	160
3	20	36	52	68	84	100	116	132	148	164
4	24	40	56	72	88	104	120	136	152	168
5	28	44	60	76	92	108	124	140	156	172
6	32	48	64	80	96	112	128	144	160	176
7	36	52	68	84	100	116	132	148	164	180
8	40	56	72	88	104	120	136	152	168	184
9	44	60	76	92	108	124	140	156	172	188

5.5.9. MCU Speed (B)

MCU Speed (B)	
Setting	**Description**
Default Setting:	1
Options:	0-1
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (M) MCU Speed

Description:	**MCU Speed** controls the speed of the Micro Controller Unit in the radio.
	• The default setting is 0 for low speed.
	  • Reduces current consumption.
	• A setting of 1 is for high speed.
	  • Required for UDP operation.
	  • Required for 230 KBaud data port rate.
	• A setting of 3 is for very high speed.
	  • Required for AES Encryption.

5.5.10. Remote LED (C)

Note: **Remote LED** is shown in the menu but is NOT supported in the MM2-M13 Serial Radio.

5.5.11. Retry Time Out (8)

Retry Time Out (8)	
Setting	**Description**
Default Setting:	255
Options:	8-255
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (8) Retry Time Out

Retry Time Out (8)	
Setting	**Description**

Description:	The **Retry Time Out** parameter in a Slave or Repeater sets the delay the unit waits before dropping the connection to a Master or Repeater in Multipoint mode.
	• The factory default is set at the maximum of 255.
	  • The maximum setting means that if 1 packet in 255 is sent successfully from the Master to the Slave or Repeater, the link is maintained.
	  • The minimum setting is 8, which allows a Slave or Repeater to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Master.
	• The function in the Master is effectively the same.
	  • With a setting of 255, the Master allows a Slave or Repeater to stay connected as long as 1 packet in 255 is successfully received at the Master.
	• The **Retry Time Out** parameter is useful when a Multipoint network has a roving Master or Slave(s).
	  • As the link gets weaker, a lower setting allows a poor link to break in search of a stronger one.
	• Setting **Retry Time Out** to 20 is recommended in areas where several FreeWave networks exist.
	  • This setting allows Slaves and Repeaters to drop the connection if the link becomes too weak, while at the same time prevents errant disconnects due to interference from neighboring networks.
	Note: While intended primarily for Multipoint networks, the **Retry Time Out** parameter can be changed in Point-to-Point networks. However, do NOT set the value in Point-to-Point mode to less than 151.

5.5.12. RF Data Rate (4)

RF Data Rate (4)	
Setting	**Description**
Default Setting:	2
Options:	• 2 - 153.6 kbps • 3 - 115.2 kbps
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (4) RF Data Rate

RF Data Rate (4)	
Setting	**Description**
Description:	FreeWave radios have two settings, **2** and **3**, for the **RF Data Rate**. • The **RF Data Rate** should not be confused with the serial port **Baud Rate**. • Use setting 2 (RF Speed of 153.6 kbps) when the radios are close together and data throughput needs to be optimized. • Use setting 3 (RF Speed of 115.2 kbps) when the radios are farther away and a solid data link is preferred over data throughput. • In Multipoint networks, the **RF Data Rate** MUST be identical on all radios. • Any radio with an **RF Data Rate** different from the Master will not establish a link. • In Point-to-Point networks, the Master's settings take precedence over the Slave's settings.

5.5.13. RF Xmit Power (5)

RF Xmit Power (5)	
Setting	**Description**
Default Setting:	10
Options:	0 (zero) to 10
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (5) RF Xmit Power
Description:	The **RF Xmint Power** option sets the RF output transmit power of the radio.

5.5.14. RTS to CTS (7)

RTS to CTS (7)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0-2
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (7) RTS to CTS

RTS to CTS (7)	
Setting	**Description**

Description:	**Note**: The **RTS to CTS** menu option is under the **Radio Parameters** menu.
	
	The **RTS to CTS** parameter is used to allow the RTS line on the Master radio to control the CTS line of the Slave.
	• This pass-through control is enabled in both Point-to-Point and Point-to-MultiPoint networks.
	  • In Multipoint networks, the **Master RTS** line controls all Slave's CTS lines.
	  • When enabled, the CTS line ceases to function as Flow Control.
	  FREEWAVE Recommends: Do NOT enable this feature when operating at Baud Rates above 38.4kB.
	• The default setting of **0** disables the **RTS to CTS** function.
	• A setting of **1** enables RTS-CTS control.
	  • With an **RTS to CTS** setting of **1**, the Master senses the RTS line prior to all scheduled packet transmissions.
	  • If the state has changed, the Master transmits a message to the Slave with the new status.
	  • This transmission occurs regardless of data being sent.
	  • If data is ready to be sent, the RTS status message is sent in addition to the data.
	• In Point-to-Point mode, the Master continues sending the new status message until it receives an acknowledgment from the Slave.
	• In Multipoint mode, the Master repeats the message the number of times equal to the **Master Packet Repeat** value in the **Multipoint Parameters** menu.
	• Master transmit times are completely asynchronous to the occurrence of any change of the RTS line.
	  • The latency time from RTS to CTS is variable.
	  • The **Max and Min Packet Size** parameters in the **Radio Parameter** menu determine this duration.
	  • Setting both parameters to their maximum value of **9** produces a maximum latency time of approximately 21 ms, if there are no Repeaters in the network.
	  • At the minimum settings for **Max and Min Packet Size** (**0**), the time is approximately 5.9ms.
	• **RTS-CTS** setting **2** is described in detail in the Application Note **#5437 DTR to CTS Line Alarm Feature** (available at http://support.freewave.com/).

- Latency can increase significantly if packets are lost between the Master and Slave.
  - In Point-to-Multipoint mode, no absolute guarantee is made that the state change is communicated to all Slaves.
  - In Multipoint networks with Repeaters present, the latency is cumulative for each serial Repeater.

Example: If the latency between the Master and the first Repeater is 15 ms AND two serial Repeaters are present, the total latency is 45 ms.
(M-R1 (15 ms) + R1-R2 (15 ms) + R2-S (15 ms) = 45 ms).

Important!: The **RTS to CTS** feature does NOT function in Point-to-Point networks that contain a Repeater.
If this feature is needed in such a network, change the mode to Point-to-Multipoint.

- If **DTRConnect** is enabled and set to **2**, the **RTS to CTS** feature will not work.
- If the **DTRConnect** is enabled and set to **1**, the **RTS to CTS** mode takes precedence over the functionality of the CTS line on the Slave relating to the **DTRConnect** feature.

5.5.15. Single Freq (4)

The **Single Freq** option is used to set which specific frequency the MM2-M13 Serial Radio uses when set to **Single Frequency Mode**.

Note: When set to **Single Frequency Mode**, the **(0) FreqKey** shows a value of **15**.

Single Freq (4)	
Setting	**Description**
Default Setting:	131
Options:	76 to 248 **Note**: See Single Frequency Setting (on page 114)
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (0) FreqKey > (F) More > (4) Single Freq
Description:	The **Single Frequency** parameter is used to set the single frequency the radio operates on.

5.5.16. Slave Security (6)

Slave Security (6)	
Setting	**Description**
Default Setting:	1
Options:	• 0 - Enabled • 1 - Disabled

Slave Security (6)	
Setting	**Description**
Setup Terminal Menu:	(3) Edit Radio Transmission Characteristics > (6) Slave Security

Description:	**Slave Security** is used to allow Slave radios to accept transmissions from a Master not included in the Call Book.
	• The default setting is **0**, **Slave Security Enabled**.
	  • This allows only a Master listed in the Slave's Call Book to link to that Slave.
	• Using a setting of **1** disables **Slave Security**.
	  • This allows any Master to call the Slave.
	  • **Slave Security** has no effect in Point-to-Multipoint networks where the Network ID is not set to 255.
	  • **Slave Security** MUST be set to **1** when the unit is operating in **Mode 6 Slave/Master Switchable** or a **Point-to-Point** network where the Slave needs to accept calls from more than 10 different Masters.
	  • When **Slave Security** is set to **1**, the radio accepts calls from any other FreeWave radio.
	  • Additional network security measures can be taken to prevent unauthorized access (e.g., changing default settings for **FreqKey**, **Hop Table**, or **Frequency Zones**).

5.5.17. Xmit Rate (3)

Xmit Rate (3)	
Setting	**Description**
Default Setting:	1
Options:	0-1
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (3) Xmit Rate
Description:	Two settings for the **Transmit Rate** parameter are available: **1** and **0**. • The setting for normal operation of the radio is a **Transmit Rate 1**. • When set to **Transmit Rate 0**, the radios transmit back and forth continuously. • **Transmit Rate 0** is useful to gauge signal strength in Point-to-Point mode. • In Point-to-Point operation, **Transmit Rate 0** should be used only as a diagnostic tool and not for normal operation. • The strength of the signal may be gauged by the Clear to Send LED. • A solid red CTS LED ( ) indicates a strong signal, while a blinking CTS LED ( ) indicates a weaker signal.

6. Configuring Point-to-MultiPoint Networks

When installing Multipoint networks, it is important to do some up front planning around the devices to implement and the route the data is going to take back to the Master. A Multipoint network can contain these devices:

- Only one Master. All communications are from and to the Master.
- An unlimited number of Slave radios (remote sites).
- An unlimited number of Repeaters between any Slave and the Master.
- Serial Repeaters can be Slave radios and Repeaters at the same time.

This section provides details specifically to a Multipoint network:

- Point-to-MultiPoint network characteristics.
- Using the **Network ID** or Call Book to establish which radios in the network can communicate with each other.
- Using **Subnet IDs** to route traffic through the network, back to the Master.
- Settings and recommendations for additional parameters that apply to a Multipoint network.
- Conserving power in devices within the network.
- Running network diagnostics.

6.1. Point-to-MultiPoint Network Characteristics

A Point-to-MultiPoint network has these unique characteristics.

- Golden Settings (on page 52)
- Master-to-Slave Communications (on page 52)
- Slave-to-Master Communications (on page 52)

6.1.1. Golden Settings

A Point-to-MultiPoint network requires that the Golden Settings (on page 36) are set the same on all radios in the network.

> **Note**: If several independent Multipoint networks are located in close proximity, the planning becomes more critical. In such cases, it becomes very important to include as much frequency and time diversity as possible through use of different **Min and Max Packet Size**.

In some instances, the use of the **MultiMaster Sync** option may be required.

- For more information, about the **MultiMaster Sync** setting, see Application Note #5412, **Synchronizing Collocated Masters** (available at http://support.freewave.com/) or contact FreeWave Technical Support.
- In almost all Multipoint networks, the **Frequency Key** is the same for all radios.
- In other networks, where parallel Repeaters are used, the **Frequency Key** value needs to change.

6.1.2. Master-to-Slave Communications

Master-to-Slave communications within a Multipoint network have these characteristics:

- Data packets sent from the Master include a 32-bit CRC.
- The Master repeats its data broadcast between 0 to 9 times, depending on the setting in the **Master Packet Repeat** setting. For more information, see Master Packet Repeat (1) (on page 66).
- A Slave or Repeater does not send acknowledgments to the Master when it receives data.
  - When any Slave in the network receives the data packet from the Master with the 32-bit CRC, that Slave ignores any additional repeats of the data, and passes the data to its data port.
- Repeaters in the network send data to Slave radios and other Repeaters.

6.1.3. Slave-to-Master Communications

Slave-to-Master communications within a Multipoint network have these characteristics:

- Data packets sent from the Slave to the Master include a 32-bit CRC.
- When the Master successfully receives data, it sends an acknowledgment to the Slave and passes the data to its data port.

6.2. Quick Start on a Point-to-Multipoint Network

This procedure sets up two radios in Point-to-Multipoint mode. This mode allows for a Master to communicate with several Repeaters and Slaves simultaneously.

1. Connect the radio to the serial port of a computer either through a serial cable or via the diagnostics cable.
2. Connect the radio to a power source.

   > **Important!**: Power supply ranges and recommendations vary depending on model. Verify the specifications for the model prior to connecting power.

3. Open a terminal emulator session and use these settings when connecting the radio:
   a. Connect to COMx (where 'x' is the number of the COM port being connected).
   b. Set these parameters to:
      i. **Data Rate** = `19200`
      ii. **Data Bits** = `8`
      iii. **Parity** = `None`
      iv. **Stop Bits** = `1`
      v. **Flow Control** = `None`
4. Press the **Setup** button on the radio.
   If using the diagnostics cable, type <Shift+U>.
   - The three LEDs on the radio should all turn green ( ), indicating Setup mode.
   - The **Main Menu** appears in the window.
5. Type `0` and press <Enter> to access the **Operation Mode** menu.
6. Type `2` and press <Enter> to set the radio as a Point-to-MultiPoint Master OR
   Type `3` to set the radio as a Point-to-MultiPoint Slave.
7. Press <Esc> to return to the Main Menu.

   > **Note**: A MultiPoint network can have only one Master, unless running in Multi-Master Synch mode.

8. On the Main Menu, type `1` and press <Enter>.
9. Change the **Baud Rate**, **Data, Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
10. Press <Esc> to return to the Main Menu.
11. On the **Main Menu**, type `3` and press <Enter>.
12. Set these parameters so they are the same on all radios in the network:
    - **FreqKey**
    - **Max Packet Size**
    - **Min Packet Size**
    - **RF Data Rate**

The **Frequency Key** option is located in the **F** submenu after `0` is typed to access the Frequency Key menu in Main Menu `3`.
Changing these values may help to eliminate interference from other FreeWave networks.

13. Press <Esc> to return to the Main Menu.
14. On the **Main Menu**, type `5` and press <Enter>.
15. In the **Network ID** field, enter the value to any value between `1` and `4095`.

FREEWAVE Recommends: Set the **Network ID** to the last three or four digits of the Master radio's serial number if it is below 4095.
This value MUST be the same in all radios in the network

Note: A setting of `255` disables the **Network ID** feature and enables the Call Book feature.

16. Press <Esc> to exit the Setup menu and resume normal radio operation.

6.3. Point-to-MultiPoint Operation LEDs

	Master			Slave			Repeater		
Condition	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**
Powered, not linked	Solid red bright	Solid red dim	Off	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Repeater and Slave linked to Master. No data.	Solid red bright	Solid red dim	Off	Solid green	Off	Solid red bright	Solid green	Solid red dim	Solid red bright
Repeater and Slave linked to Master. Master sending data to Slave.	Solid red bright	Solid red dim	Off	Solid green	Off	Solid red bright	Solid green	Solid red dim	Solid red bright
Repeater and Slave linked to Master. Slave sending data to Master.	Solid green RCV data or Solid red bright	Solid red dim	Intermittent flash red	Solid green	Intermittent flash red	Solid red bright	Solid green	Solid red bright	Solid red bright
Master with diagnostics program running.	Solid red bright	Solid red dim	Intermittent flash red	Solid green	Intermittent flash red	Solid red bright	Solid green	Solid red bright	Solid red bright

Note: * In an idle condition, the CTS LED is solid red with a solid link, as the link weakens the CTS LED on the Repeater and Slave begins to blink.

6.4. Overlapping Multipoint Networks

Overlapping MultiPoint networks may be set up effectively when several key parameters are set correctly. Overlapping MultiPoint networks are defined as networks using different Master radios, which share or overlap in a specific geographic area. It may also include collocated radios configured into different networks.

For more information, see Application Note #5412, **Synchronizing Collocated Masters (Multi-Master Sync Mode)** (available at http://support.freewave.com/).

Collocated MultiPoint networks require these parameters be unique for each network:

- Network ID (unless using the Call Book)
- Frequency Key (with Repeater Frequency)
- Max Packet Size
- Min Packet Size

Note: For more information about the installation of Point-to-MultiPoint networks, contact FreeWave Technical Support.
See Contact FreeWave Technical Support (on page 7)

6.5. Establishing Communication with Other Radios in a Multipoint Network

For the radios in the network to communicate successfully, the radio needs to know what other devices are available for them to communicate with. Use the **Network ID** or the Call Book.

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

6.5.1. Using the Network ID in Multipoint Networks

The **Network ID** parameter is located on the **MultiPoint Parameters** tab. Assign each radio in a single network the same **Network ID**. Slave radios link with the first Master or Repeater it hears that has a matching **Network ID**.

When setting the **Network ID**:

- The value can be any value between 1 and 4095, except 255.
  - 255 enables the Call Book.
- To help ensure the ID is unique to the network, avoid using numbers that coincide with nearby landmarks or highways.

Example: Use the last four digits of the Master serial number if it is below 4095.
This is ensured to be unique and does not overlap with other nearby FreeWave networks.

- Use the **Network ID** function in conjunction with the **Subnet ID** feature (if necessary) to route data through the radio network.

6.5.2. Using Call Book in Multipoint Networks

Important!: Although NOT recommended, the Call Book is an option in MultiPoint networks. If the **Network ID** feature is used in a MultiPoint network, no entries are needed in the Call Book of any of the radios.

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

Important!: Using the Call Book in a MultiPoint network can cause delay in resuming communications if a Master is damaged.

Note: For information about setting the Call Book, see Using Call Book in Point-to-Point Networks (on page 81).

In a MultiPoint network, the Slave radios and Repeaters are not listed in the Master radio's Call Book. Slave radios must have the Master and any Repeater it is going to use in its Call Book.

These examples show the Call Book of a MultiPoint network comprised of a Master, Repeater, and Slave in which the Slave can communicate either through the Repeater or directly to the Master.

MultiPoint Master Call Book (Unit Serial Number 900-0001)

Entry	Number	Repeater 1	Repeater 2
(0)	000-0000		
(1)	000-0000		

Note: No serial number entries are necessary in the Master's Call Book.

MultiPoint Repeater Call Book (Unit Serial Number 900-0002)

Entry	Number	Repeater 1	Repeater 2
(0)	900-0001		
(1)	000-0000		

MultiPoint Slave Call Book (Unit Serial Number 900-0003)

Entry	Number	Repeater 1	Repeater 2
(0)	900-0001		
(1)	900-0002		
(2)	000-0000		

At times, the Slave radios need to be forced to go through a specific MultiPoint Repeater. In this scenario, the Slave radio's Call Book should contain only the serial number for that Repeater as the entry on line **0**.

6.5.3. Programming Point-to-Multipoint Extended Call Book

In a MultiPoint network, Slave radios can be programmed to roam between Master radios and Repeaters using the MultiPoint **Extended Call Book** function. Slave radios with Call Book, as configured in this procedure, communicate with any radio whose serial number appears in any of the three columns.

Procedure

1. Set the **Network ID** to `255`.
2. In the Call Book, enter `999-9999` as the last entry in the first and second columns.
3. In the Call Book, set **Entry to Call** to **All**.

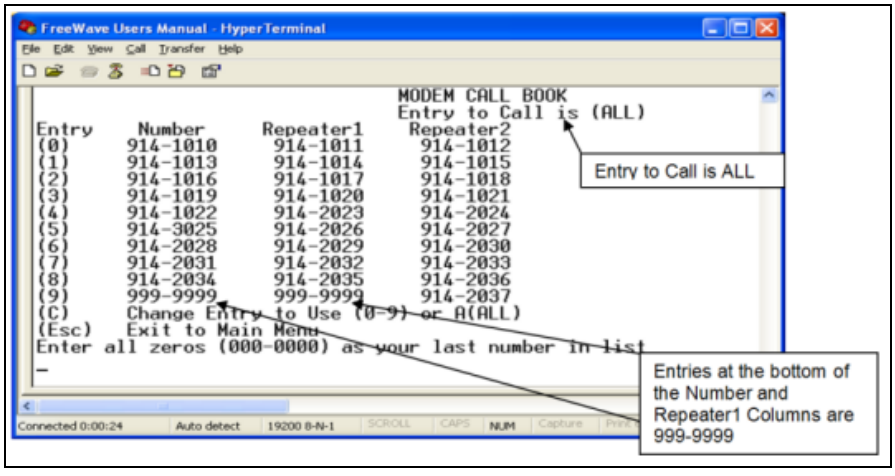


Figure 17: HyperTerminal PTMP Extended Call Book

6.6. Routing Communications through the Network

When using the **Network ID**, a Repeater or Slave links to the first Repeater or Master it hears with the same ID.

- Use Subnet IDs to determine the path a Repeater or Slave uses to communicate back to the Master.
- Subnet IDs are particularly helpful to force:
  - Two Repeaters in the same network to operate in series rather than in parallel.
  - Slave radios to communicate to a specific Repeater for load balancing purposes.

Note: Forcing the communications path optimizes the performance of the network by ensuring the Repeater or Slave links to a Repeater or Master with robust RF communications. Subnet IDs can help to minimize latency.

6.6.1. Assigning Subnet ID Values

Subnet IDs consist of two parts, both available on the **MultiPoint Parameters** tab:

- **Rx** - This setting identifies which radio a Repeater or Slave listens to.
  - In the terminal interface, this is the **Rcv Subnet ID**.
- **Tx** - This setting identifies the ID this device transmits on and which devices listen to it.
  - The **Tx Subnet ID** parameter is relevant for MultiPoint Master radios and Repeaters **only**.
  - In the terminal interface, this is the **Xmt Subnet ID**.
- The default (disable) setting for both **Rx** and **Tx** is **F, F**.
  - This is a visual way to indicate that the device is the final in the line of communication and does not use a subnet ID.
- A MultiPoint Slave with a **Subnet ID** of **F, F** does not roam from one Repeater or network to the next.
  - It only links to a Master or Repeater that has either a **Transmit Subnet** setting of 0 or an **F, F Subnet ID**.
- Setting both **Rx** and **Tx Subnet ID** to 0 allows a mobile Slave to roam from subnet to subnet, and possibly from network to network, provided the **Network ID**, **Max and Min Packet Size**, and **RF Data Rates** are the same between networks.

The examples in this section show the subnet definitions from the Master radio through the network to the Slave radios. When the subnet path is defined, the Slave radios can follow the route back to the Master.

Example 1: Subnet and Specific Path Communication

This example shows a network in which subnet IDs are used to force communications along a specific path.

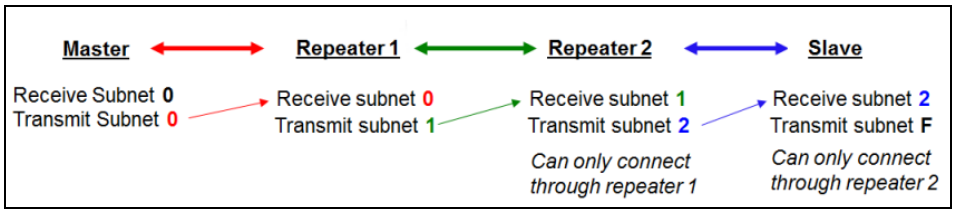


Figure 18: Subnet and Specific Path Communication

Subnet and Specific Path Communication			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0	0	• The default settings (**F, F**) actually use **0, 0**. • The **Rx Subnet** on the Master has no effect on the network.
Repeater 1	0	1	**Rx Subnet** = 0 forces communication through the Master.
Repeater 2	1	2	• **Rx Subnet** = 1 forces communication through Repeater 1. • Repeater 1 transmits on SubnetID 2.
Slave	2	F	• **Rx Subnet** = 2 forces communication through Repeater 2. • The Slave is the end of the network, so its **Tx Subnet** is **F**.

Example 2: Subnet and Communication Required through Repeaters

This example shows:

- Repeater 2 must communicate through Repeater 1.
- The Slave connected to Repeater 1 must route through Repeater 1.
- The other two Slave radios must route through Slave/Repeater 2.

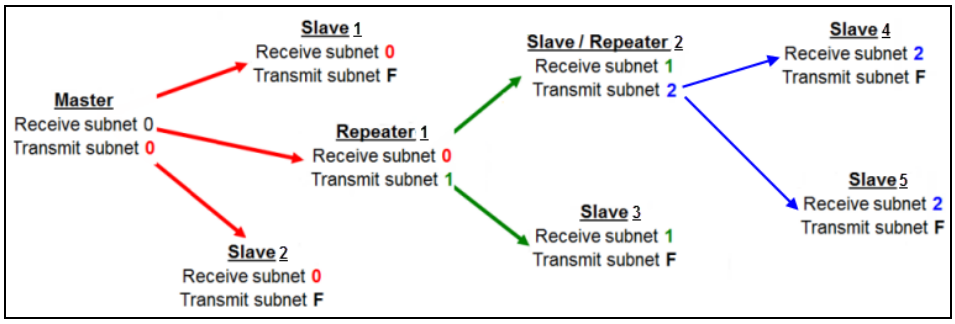


Figure 19: Subnet and Communication Required through Repeaters

Subnet and Communication Required through Repeaters			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0	0	• The default settings (**F, F**) actually use **0, 0**. • The **Rx Subnet** on the Master has no effect on the network.
Slave 1	0	F	• **Rx Subnet** = 0 forces communication through the Master. • The Slave does not transmit to any device except the Master, so its **Tx Subnet** is **F**.
Repeater 1	0	1	• **Rx Subnet** = 0 forces communication through the Master. • Repeater 1 transmits on SubnetID 1.
Slave 2	0	F	**Rx Subnet** = 0 forces communication through the Master.
Slave/Repeater 2	1	2	• **Rx Subnet** = 1 forces communication through Repeater 1. • It transmits on **Tx Subnet 2** to Slave 4 and 5.
Slave 3	1	F	• **Rx Subnet** = 1 forces communication through Repeater 1. • The Slave does not transmit to any device except Repeater 1, so its **Tx Subnet** is **F**.
Slave 4	2	F	**Rx Subnet** = 2 forces communication through Slave/Repeater 2.
Slave 5	2	F	**Rx Subnet** = 2 forces communication through Slave/Repeater 2.

Example 3: Subnet and Optional Slave Communication

This example shows:

- Repeater 1 must talk directly to the Master.
- Repeater 2 must talk directly to Repeater 1.
- Slave 1, 2, and 3 are forced along the direction of the solid lines.
- Slave 4 may link to the first Master or Repeater it hears in the network.

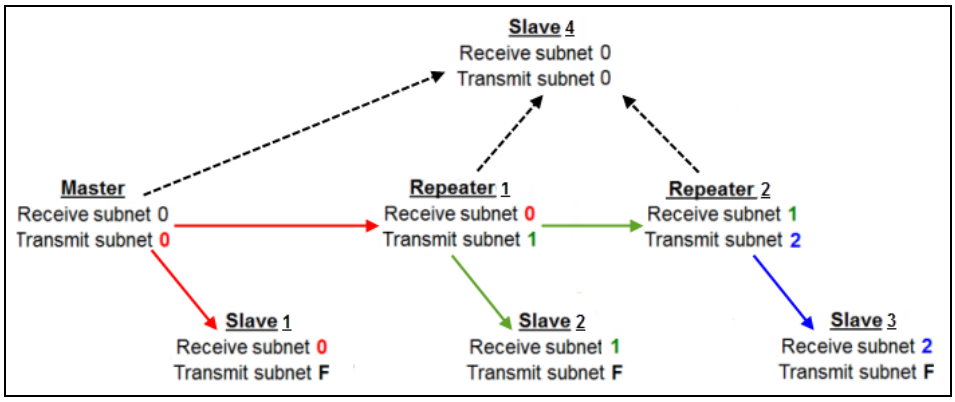


Figure 20: Subnet and Optional Slave Communication

Subnet and Optional Slave Communication			
Radio	**Rx**	**Tx**	**Additional Information**
Master	0 or F	0 or F	• The default settings (**F, F**) actually use **0, 0**. • The **Rx Subnet** on the Master has no effect on the network.
Repeater 1	0	1	**Rx Subnet** = 0 forces communication through the Master.
Repeater 2	1	2	• **Rx Subnet** = 1 forces communication through Repeater 1. • Repeater 1 transmits on SubnetID 1.
Slave 1	0	0 or F	**Rx Subnet** = 0 forces communication through the Master.
Slave 2	1	0 or F	**Rx Subnet** = 1 forces communication through Repeater 1.
Slave 3	2	0 or F	**Rx Subnet** = 2 forces communication through Repeater 2.
Slave 4	0	0	The **0, 0** setting allows the Slave to link with the first Master or Repeater it hears with the same **Network ID**.

6.7. Setting Other Multipoint Parameters

The other MultiPoint Parameters options are used to modify several different parameters in the radio that determine the characteristics of a MultiPoint network.

These settings are available in the **MultiPoint Parameters** menu in the terminal interface.

> **Note**: See the Parameter Preference (on page 8) for a description of the parameter table's content.

6.7.1. 1 PPS Enable/Delay (9)

> **Important!**: When **1 PPS** is enabled, the Master radio must have a 1 PPS pulse on its DTR pin, otherwise the RF network does not function.

1 PPS Enable/Delay (9)	
Setting	**Description**
Default Setting:	255
Options:	0 (zero) to 255 **Note**: Pulse-per-second 255 is **Off**.
Terminal Menu:	(5) Edit Multipoint Parameters > (9) 1 PPS Enable/Delay
Description:	The **1 PPS Enable/Delay (9)** setting allows a 1PPS signal to propagate from the Master to all Slaves in a MultiPoint network. When this parameter is enabled a properly generated pulse applied on the DTR line of the Master provides a 1 PPS pulse on the CD line of any Slave in the network.

Setup 1PPS Enable/Delay

1. On the Master radio, set the **1 PPS Enable/Delay** parameter to 0.

   > **Note**: The Master must have a 1 PPS pulse on the DTR pin, otherwise the RF network will not function.

2. Enable the **1 PPS Enable/Delay** parameter on the Slave radios.
   Slave radios are calibrated at the factory.

Calibrate a Slave Radio in 1PPS Enable/Delay Mode

1. On the Master radio, trigger an oscilloscope on the 1 PPS pulse on the DTR line.
2. Monitor the CD line of the Slave radio.
3. If the timing on the Slave radio differs from the Master it may be adjusted via the value in the Slave radio's **1 PPS Enable/Delay** parameter.

Notes

- The difference in time between each incremental integer value is 542.534 nanoseconds (ns).
- Changing the parameter to higher values decreases the Slave radio time delay and changing the parameter to lower values increases the time delay.
- When properly calibrated, the CD line Slave radio outputs a pulse that goes high for about 2 ms in sync with the 1 PPS pulse on the Master radio.
- The output on the Slave radio occurs within 20 microseconds of the input to the Master.

6.7.2. Diagnostics (B)

Diagnostics (B)	
Setting	**Description**
Default Setting:	(0) Diagnostics
Options:	0 to 129
Terminal Menu:	(5) Edit Multipoint Parameters > (B) Diagnostics

Description:	**Diagnostics**, provides diagnostic data at the Master radio in parallel with application data.
	• The diagnostic program MUST be run from the Master radio.
	• **Diagnostics** requires:
	  • **Diagnostics** set from `0 - 129` in the Master.
	  • A second computer or serial connection to run the diagnostics software.
	  • A diagnostics cable. (Available from FreeWave Technologies, Inc..)
	  • Diagnostics software.
	Note: For more information on Diagnostics, Contact FreeWave Technical Support (on page 7)

6.7.3. DTR Connect (4)

DTR Connect (4)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	• **(0) Off** - When set to off in the Slave radio, the radio transmits when the data is received. • **(1) DTR Sensing** - Forms a Point-to-Point link with the Master radio when the DTR line is high to send data. • **(2) Burst Mode** - The radio transmits data in bursts.

DTR Connect (4)	
Setting	**Description**
Terminal Menu:	(5) Edit Multipoint Parameters > (4) DTR Connect
Description:	Determines how the radio sends its data. **Note**: This mode is valuable when a network has many low data rate devices and to increase overall network capacity. • If **DTR Connect** is set to **1** and the **RTS to CTS** function is enabled on the radio, then **RTS to CTS** takes precedence over **DTR Connect**. • If **DTR Connect** is set to **2** and **RTS to CTS** is enabled, then **RTS to CTS** is ignored. The radio has two separate transmit and receive user data buffers of 2kb each. **Caution**: In case of a buffer overflow, the radio outputs unpredictable data.

6.7.4. Local Access (E)

Local Access (E)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0-1 • 0 = Normal mode • 1 = Enables Local Access
Terminal Menu:	(5) Edit Multipoint Parameters > (E) Local Access
Description:	**Local Access** is used to access an MM2-M13 Serial Radio Multipoint Slave with a local Master. **Important!**: This Master is NOT the network master. **Note**: For more information, see Application Note #5457, Local Mode (available at http://support.freewave.com/). Registration is required to use this login.

6.7.5. Master Packet Repeat (1)

Master Packet Repeat (1)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0 to 9
Terminal Menu:	(5) Edit Multipoint Parameters > (1) Master Packet Repeat
Description:	In a Point-to-MultiPoint network, Slave radios do not acknowledge transmissions from the Master. • If Slave radios did acknowledge all data transmissions, in a large network, the Master would soon become overwhelmed with acknowledgments from the Slaves. • Without acknowledgments, 100% confidence every Slave radio has received every packet cannot be met. • To address this issue, change the **Master Packet Repeat** parameter, assigning a value between 0 (the packet is transmitted once) to 9 (the packet is transmitted 10 times). For networks with solid RF links, this parameter should be set to a low value (e.g., 1 or 2). • If a network has some weak or marginal links it should be set with higher values. • If a Slave radio receives a good packet from a Master more than once it discards the repeated packets. • Similarly, after a MultiPoint Repeater receives a good packet from the Master, it discards any further repeated packets. • In turn, the Repeater sends the packet out to the next Repeater or Slaves the number of times corresponding to its own **Master Packet Repeat** setting. Increasing the **Master Packet Repeat** setting increases the probability of a packet getting through, but also increases latency in the network because each packet from the Master or Repeater is being sent multiple times. **Note**: Therefore, it is important to find the optimal mix between network robustness, throughput, and latency. In general, a setting of 2 to 3 works well for most well designed networks. The **Master Packet Repeat** parameter may be set to 0 if the user software is capable of, or requires acknowledgment. In this case, if the Master sends a packet that the Slave radio does not receive, the user software controls the retries as needed.

6.7.6. Master Packet Repeat in Multipoint Networks with Repeaters

The **Master Packet Repeat** parameter must be set in MultiPoint Repeaters because a Repeater appears as a Master to a Slave radio.

Therefore, the Repeater sends the packet out the number of times corresponding to its own **Master Packet Repeat** parameter setting. If this parameter is set improperly the reliability of the overall network may be diminished.

Example: If a Master's **Master Packet Repeat** parameter setting is 3, the link between the Master and Repeater should be robust.
If the Repeater's **Master Packet Repeat** parameter setting is 0, this could cause marginal links between the Repeater and the Slaves.
The Slaves communicating through this Repeater only receive the initial packet from the Master with no repeats.
Therefore, if the packet is not received on the first try, the Slave radio does not respond as expected.

Note: The **Master Packet Repeat** parameter setting in any MultiPoint Repeater must be **less than or equal** to the Master's setting.

6.7.7. Max Slave Retry (2)

Max Slave Retry (2)	
Setting	**Description**
Default Setting:	9
Options:	0-9
Terminal Menu:	(5) Edit Multipoint Parameters > (2) Master Slave Retry
Description:	**Max Slave Retry**, defines how many times (0 to 9) the Slave attempts to retransmit a packet to the Master before beginning to use a back-off algorithm, which is defined by the Retry Odds (3) (on page 70) setting. Slave retries stop when an acknowledgment is received from the Master.

6.7.8. MultiMasterSync (8)

MultiMasterSync (8)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0-1 • 0 = Master Sync • 1 = Otherwise
Terminal Menu:	(5) Edit Multipoint Parameters > (8) MultiMasterSync

MultiMasterSync (8)	
Setting	**Description**
Description:	**MultiMaster Synch**, is reserved for applications, in both Point-to-Point and Multipoint modes, with concentrations of master units where it is necessary to reduce interference between the masters. **Note**: See Application Note **#5412 Synch Colloc Master in Sync Mode** for more information (available at http://support.freewave.com/). Registration is required to use this login.

6.7.9. Network ID (6)

Network ID (6)	
Setting	**Description**
Default Setting:	0255
Options:	0-4095 (excluding 255)
Terminal Menu:	(5) Edit Multipoint Parameters > (6) Network ID
Description:	**Network ID** is used to establish Multipoint networks without using the Call Book. Set the value between 0 and 4095 (excluding 255) to enable **Network ID**. **Important!**: The default setting of 0255 enables the Call Book. • Since **Network ID** does NOT use serial numbers, Multipoint Masters and Repeaters can be replaced without reprogramming all of the Slaves in the network. • A Slave links with the first Master or Repeater that it hears that has a matching **Network ID**. • Use the **Network ID** function in conjunction with the Subnet ID (C) (on page 72) setting. • Without having the serial numbers in the Call Book, a Slave establishes communications with different Masters, though not at the same time. Tip This is very useful in mobile Multipoint applications.

6.7.10. Number Repeaters (0)

Important!: In a Multipoint network it is critical to transmission timing to configure this parameter correctly.

Number Repeaters (0)	
Setting	**Description**
Default Setting:	1
Options:	0 (zero), 1-9
Terminal Menu:	(5) Edit Multipoint Parameters > (0) Number Repeaters
Description:	• Set the **Number Repeaters** value to `0` if there are NO Repeaters in the network. • Set the **Number Repeaters** value from `1-9` if there are Repeaters in the network. **Note**: In a Point-to-MultiPoint network, the **Number Repeaters** parameter is set in the Master.

6.7.11. Radio ID (D)

Radio ID (D)	
Setting	**Description**
Default Setting:	Not Set
Options:	0 to 9999
Terminal Menu:	(5) Edit Multipoint Parameters > (D) Radio ID
Description:	**Radio ID** is used to designate a radio with an arbitrary, user selectable, four digit number that identifies the radio in diagnostics mode.

6.7.12. Radio Name (G)

Radio Name (G)	
Setting	**Description**
Default Setting:	None
Options:	A maximum of 20 alpha-characters
Terminal Menu:	(5) Edit Multipoint Parameters > (G) Radio Name
Description:	**Radio Name** is used to set a radio name in the radio settings. • The radio name can have a maximum of 20 characters (letters, numbers, or spaces). • This value is recognized by some FreeWave diagnostics programs to help identify the radio. • This setting has no impact on radio communications.

6.7.13. Repeater Frequency (5)

Repeater Frequency (5)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0-1
Terminal Menu:	(5) Edit Multipoint Parameters > (5) Repeater Frequency
Description:	**Repeater Frequency** must be set to 1 in a Repeater when a **FreqKey** other than the Master is needed. • This condition occurs when parallel Repeaters in a network have overlapping areas of responsibility. • The default setting of **0** causes the Repeater to use the **FreqKey** set in **Menu 3**. • When **Repeater Frequency** is set to 0, the **FreqKey** setting must match the Master or Repeater acting as the Master for the radio.

6.7.14. Retry Odds (3)

Retry Odds (3)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0 to 9
Terminal Menu:	(5) Edit Multipoint Parameters > (3) Retry Odds

Retry Odds (3)	
Setting	**Description**
Description:	While packets transmitted from the Master to the Slave radios in a MultiPoint network are not acknowledged, packets transmitted from Slaves to the Master are acknowledged. It is possible that more than one Slave attempts to transmit to the Master at the same time. Therefore, it is important that a protocol exists to resolve contention for the Master between Slaves in the network. This is addressed through the Max Slave Retry (2) (on page 67) and **Retry Odds (3)** parameters. • After the Slave has unsuccessfully attempted to transmit the packet the number of times specified in the **Max Slave Retry** parameter, it attempts to transmit to the Master on a random basis. • The **Retry Odds** parameter determines the probability that the Slave attempts to retransmit the packet to the Master; a low setting assigns low odds to the Slave attempting to transmit. • Conversely, a high setting assigns higher odds. **Example**: Consider two different Slave radios in a MultiPoint network, one with a strong RF link and the other with a weak RF link to the Master. If a Slave has a weak or poor link, set the **Retry Odds** parameter to 0 as it may become a chatty Slave and lockup the network, causing a loss of communication. • When the **Retry Odds** parameter is set to 0, after the Slave has exhausted the number of retries set in the **Max Slave Retry** parameter and still not gained the Master's attention, the Slave's data buffer is purged. **FREEWAVE Recommends**: A **Retry Odds** parameter set to 0 is recommended for most networks.

6.7.15. Slave/Repeater (A)

Slave/Repeater (A)	
Setting	**Description**
Default Setting:	0 (zero)
Options:	0 to 1 • 0 = Normal • 1 = Enable Slave / Repeater
Terminal Menu:	(5) Edit Multipoint Parameters > (A) Slave/Repeater

Slave/Repeater (A)	
Setting	**Description**
Description:	The **Slave/Repeater** mode allows a radio in a MultiPoint network to switch between Slave and Repeater functions. • When in this mode, a radio repeats any packets sent across the network as well as uses the data port. • This allows one radio at one site. **Note**: To operate a radio as a MultiPoint **Slave/Repeater**, use the **Multipoint Parameters** menu and set the operation mode to `Multipoint Repeater (7)` and `Slave/Repeater (1)`.

6.7.16. Subnet ID (C)

Option **C**, **Subnet ID**, only works in Multipoint networks using the **Network ID** option. In a Multipoint network, a Slave or Repeater connects with the first Repeater or Master it hears with the same **Network ID**.

Subnet ID is particularly helpful to force two Repeaters in the same network to operate in series rather than in parallel or to force Slaves to communicate to a specific Repeater for load balancing purposes. Two components exist with regard to the **Subnet ID**:

- **Rx Subnet ID** - This setting identifies the radio a Repeater or Slave listens to.
- **Xmit Subnet ID** - This setting identifies the ID the device transmits on and the devices listening to it. The **Xmit Subnet ID** parameter is relevant for Multipoint masters and repeaters only.

The default (disable) setting for both **Rx** and **Xmit** is **F**.

Important!: Changing these settings on the Master is NOT recommended under normal circumstances.

In some Multipoint Networks, the **FreqKey** is at the same setting for all radios. In other networks, where parallel Repeaters are used, the **FreqKey** value needs to change.

- If both **Rx Subnet ID** and **Xmit Subnet ID** are set to 0 (zero), the **Subnet ID** shows **Roaming** in the menu.
  - This setting allows a mobile slave to roam from subnet to subnet and possibly from network to network.

Figure 21 shows a network where **Subnet IDs** are used to force communications. In this example:

- Repeater 1 must talk directly to the Master.
- Repeater 2 must talk directly to Repeater 1.
- Slaves 1, 2, and 3 are forced along the direction of the solid lines.
- Slave 4 links to the first Master or Repeater it hears.

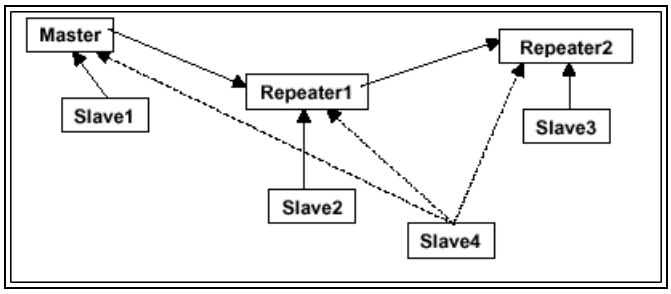


Figure 21: Subnet IDs Forcing Communication

Subnet ID Settings			
Radio	**Rx Subnet ID**	**Xmit Subnet ID**	**Other Information**
Master	F	F	The Master uses 0,0.
Master	0	0	• The **Xmit Subnet ID** value may be set in the Master. • The default settings (**F, F**) actually use **0, 0**. • The **Rx Subnet** on the Master has no effect on the network.
Repeater1	0	1	**Rx Subnet** = 0 forces communication through the Master.
Repeater2	1	2	• **Rx Subnet** = 1 forces communication through Repeater 1. • Repeater 1 transmits on SubnetID 1.
Slave1	0	0 or F	**Rx Subnet** = 0 forces communication through the Master.
Slave2	1	0 or F	**Rx Subnet** = 1 forces communication through Repeater 1.
Slave3	2	0 or F	**Rx Subnet** = 2 forces communication through Repeater 2.
Slave4	0	0	The **0, 0** setting allows the Slave to link with the first Master or Repeater it hears with the correct **Network ID**.

6.8. Conserving Power

Power consumption can be essential, especially for remote sites that are difficult to access. Use these options on the **Transmission Characteristics** tab to conserve power.

These settings are available in the **Radio Transmission Characteristics** menu in the terminal interface.

- **Low Power Mode** - Available in MultiPoint Slaves using RS232.
  - Conserves power primarily by dimming the radio's LEDs.

  Note: For more information, see Low Power Mode (on page 74).
- **Remote LEDs** - If the radio has the optional 20-in connector, use this option to connect remote LEDs through the diagnostics port.

This feature may be used to save power in MultiPoint Repeaters where the other options are not available.

Note: For more information, see Remote LED (C) (on page 45).

6.8.1. Low Power Mode

Note: This setting applies only to MultiPoint Slave radios using the RS232 protocol. **Low Power Mode** does not work with MultiPoint Repeaters because they are constantly transmitting.

Low Power Mode	
Setting	**Description**
Default Setting:	0
Options:	Any number between 0 and 31. **Note**: The higher the number, the greater the power consumption decrease. **Warning!** For firmware version 2.68 and later, a **Low Power Mode** setting other than 0 for RS422 / RS485 causes the Slave radio to disassociate from the network.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (9) Low Power Mode

<table>
<tr><th colspan="2">Low Power Mode</th></tr>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>Description:</td><td>
The Low Power Mode setting allows a MultiPoint Slave radio to consume less power, primarily by dimming the radio's LEDs.

When set to 2 through 31, the radio sleeps between slots.

Example: A setting of 2 the radio sleeps 1 out of 2 slots; at a setting of 3 the radio sleeps 2 out of 3 slots, and so on.

When the radio is asleep, it hears nothing from the Master.

The is table shows the changes at different Low Power Mode settings.
Important!: The actual current draw depends on many factors. The table provides only a qualitative indication of supply current savings.
Note: A low number reduces latency and a high number reduces current consumption.
<table>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>0</td><td>Low power, disabled.</td></tr>
<tr><td>1</td><td>LEDs are dimmed.
Radio remains awake, radio is listening to the Master’s transmissions on every slot.
Radio’s data port is shut down if the RTS line is de-asserted (low).
In this case, the radio needs to be awakened before it is able to send data to the Master.</td></tr>
<tr><td>2</td><td>LEDs dimmed, radio sleeps every other slot.</td></tr>
<tr><td>3</td><td>LEDs dimmed, radio sleeps 2 of 3 slots.</td></tr>
<tr><td>4-31</td><td>LEDs dimmed, radio sleeps the number of slots corresponding to the setting.
Example: Using a setting of 31 the radio sleeps 30 of 31 slots.</td></tr>
</table>
</td></tr>
</table>

Low Power Mode	
Setting	**Description**

	Notes
	• Power savings occur only when the Slave radio is linked.
	  • No power savings occur when the Slave radio is transmitting data.
	  • **Low Power Mode** is of little value when a Slave has a constant, high throughput.
	  • The **MCU Speed** parameter MUST be set to `0` and the **RF Data Rate** parameter MUST be set to `3` for **Low Power Mode** to operate properly.
	• To communicate to an RS232 port of a radio that is in **Low Power Mode**, the RTS line MUST be held high to wake it up.
	  • The radio wakes up within approximately 20 milliseconds of when RTS goes high.
	  • If the Request to Send (RTS) line on the Slave radio is held high, the radio remains in normal operation regardless of the **Low Power Mode** setting.
	  • After RTS is dropped the radio reverts to the **Low Power Mode**.
	• If the radio has the DTR Connect (4) (on page 64) parameter in the **MultiPoint Parameters tab** set to `1` or `2` and if the **Low Power Mode** is enabled (set to `1 to 31`), the RTS line on the radio MUST be asserted for the **DTR Connect** feature to operate properly.
	• The diagnostic pins MUST be disabled or terminated to a cable for the sleep current in **Lower Power Mode** to match the specifications.
	  • To disable the diagnostic pins, set these options:
	  • In the **Baud Rate tab**, the Setup Port (on page 33) parameter is set to `1 (Main Only)`.
	  • In the **MultiPoint Parameters tab**, the Diagnostics (B) (on page 64) parameter is set to `0 (Off)`.
	• To realize full power savings in **Low Power Mode**, the serial port MUST be deactivated between operation.
	  • To do that the RTS line MUST be asserted.
	  • However, because RS422 / RS485 operation uses the RTS line as part of the data bus, it cannot be asserted to wake-up the radio.
	FREEWAVE Recommends: All radios set to RS422 or RS485 use a **Low Power Mode** setting of `0`.

7. Configuring Point-to-Point Networks

Point-to-Point networks are the most basic type of network and do not require much more than the setup described in the basic programming and setup section.

This section provides:

- A brief quick start to setup a Point-to-Point network.
- An LED chart for LED function within a Point-to-Point network.
- Information about programming the Call Book.

7.1. Quick Start on a Point-to-Point Network

When purchased as a pair, the FreeWave radios are shipped from the factory pre-configured with most of the settings to operate in Point-to-Point applications.

To establish a link between a pair of FreeWave radios just received from the factory, complete these steps for each radio.

Procedure

1. Connect the radio to the serial port of a computer either through a serial cable or via the diagnostics cable.
2. Connect the radio to a power source.

   Note: Power supply ranges and recommendations vary depending on model.
   Verify the specifications for the model you are using prior to connecting power.

3. Open a terminal emulator session.
4. Connect to COMx (where 'x' is the number of the COM port being connected).
5. Set these parameters to:

- Data Rate - **19,200**
- Data Bits - **8**
- Parity - **none**
- Stop bits - **1**
- Flow Control - **none**

6. Press the **Setup** button on the radio.
   If using the diagnostics cable, press <Shift+U>.
   - When in **Setup** mode, all three LEDs on the radio display solid green.
   - The **Main Menu** appears in the window.
7. Type **0** and press <Enter> to access the **Operation Mode** menu.
8. Type **0** and press <Enter> to set the radio as a Point-to-Point Master or
   Type **1** and press <Enter> to set the radio as Point-to-Point Slave.

   Note: For more information about modem modes, see Define the Radio's Role in the Network and the Network Type (on page 27).
9. Press <Esc> to return to the Main Menu.
10. On the **Main Menu**, type **1** and press <Enter>.
11. Change the **Baud Rate**, **Data, Parity**, and **Modbus RTU** to match the device that the radio is to be attached to.
12. Press <Esc> to return to the Main Menu.
13. On the **Main Menu**, type **2** and press <Enter> to update the Call Book.
14. Enter the Slave serial number in the Master's Call Book.
15. Enter the Master's Serial number in the Slave's Call Book or
    disable the Slave Security (6) (on page 49) parameter in the Slave.

    Note: For more information about setting up the Call Book, see Using Call Book in Point-to-Point Networks (on page 81).
16. On the **Main Menu**, type **3** and press <Enter>.
17. Set these parameters so they are identical on all radios in the network:
    - Frequency Key
    - Max Packet Size
    - Min Packet Size
    - RF Data Rate

    Note: The **Frequency Key** option is located in the **F** submenu after you press <**0**> to access the **Frequency Key** menu on **Main** menu <**3**>.

    FREEWAVE Recommends: Changing these settings from the factory defaults may help to eliminate interference from other FreeWave networks.
18. Press <Esc> to return to the Main Menu.

Shortly after both radios are plugged in, they should establish a link with each other and the connection is complete.

19. Using the Point-to-Point Operation LEDs (on page 80), verify that the radios are operating as expected.
20. Press <**Esc**> to exit the **Setup** menu and resume normal radio operation.

7.2. Point-to-Point Operation LEDs

	Master			Slave			Repeater		
Condition	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**	**Carrier Detect (CD)**	**Transmit (Tx)**	**Clear to Send (CTS)**
Powered, no link	Solid red bright	Solid red bright	Solid red bright	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Linked. No Repeater Sending sparse data	Solid green	Intermittent flash red	Intermittent flash red	Solid green	Intermittent flash red	Intermittent flash red	n/a	n/a	n/a
Master calling Slave through Repeater	Solid red bright	Solid red dim	Solid red bright	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red
Master linked to Repeater, not to Slave	Flashing orange	Solid red dim	Solid red bright	Solid red bright	Off	Blinking red	Solid Red bright	Solid red dim	Solid red bright
Repeater linked to Slave	Solid green	Intermittent flash red	Intermittent flash red	Solid green	Intermittent flash red	Intermittent flash red	Solid green	Intermittent flash red	Intermittent flash red
Mode 6 Waiting for ATD command	Solid red bright	Off	Blinking red	Solid red bright	Off	Blinking red	n/a	n/a	n/a
Setup Mode	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green	Solid green

7.3. Using Call Book in Point-to-Point Networks

Using the Call Book offers both security and flexibility in determining how FreeWave radios communicate with each other.

Important!: The Call Book is required in Point-to-Point networks.

FREEWAVE Recommends: While the Call Book is an option in Point-to-MultiPoint networks, FreeWave **strongly recommends** using the **Network ID** feature in most applications.
If a large MultiPoint network is implemented using the Call Book and a radio needs to be added to or replaced in the network, each radio in the network must be physically reprogrammed and the new serial number entered in the radio's Call Book.
This can be a time consuming process and can cause a delay in getting the network back up and running.
Because the **Network ID** does not use serial numbers, MultiPoint Master radios and Repeaters may be added or replaced without reprogramming each Slave radio in the network.

- The Call Book allows a maximum of 10 FreeWave radios.
  - Designate 1 to 4 Repeaters to use with each radio.
  - Designate which Slave the Master calls.

These settings are required for two FreeWave radios to communicate in Point-to-Point mode:

1. The Master radio serial number must be listed in the Slave radio's Call Book or **Slave Security** is turned off in the Slave.
2. The Slave serial number must be listed in the Master Call Book.
3. The Master must be programmed to call the Slave (**Entry to Call** option).
   a. Select the number in the **Entry to Call** field, select **All** to direct the Master to call all Slave radios.

   Note: To set the **Entry to Call** option in the terminal interface, press <C> at the Call Book menu, followed by the menu number corresponding to that Slave.
   To call any available Slave in the list, press <C> then press <A> to direct the Master to **Call All**.

It is important that the Call Book slots (0-9) are filled sequentially starting with slot 0.

- When a Master is instructed to **Call All**, it calls all Slave radios listed until it reaches the first serial number of 000-0000 (or a blank slot).
- If a serial number is entered after the all zero number or as a Repeater, the Master does not recognize it as a valid number.

Note: When entering numbers into the Call Book, define only the Repeaters in the Master's Call Book.
The Slave's Call Book only requires the Master serial number.
A Repeater need not have anything listed in its Call Book.

7.3.1. Programming Point-To-Point Extended Call Book to Use Three or Four Repeaters

In a Point-to-Point configuration, FreeWave radios can use a maximum of four Repeaters.

1. To use three or four Repeaters, program the Call Book with the Slave serial number, followed by the first two Repeaters.
2. On the next line enter 999-9999 as the radio to call.
3. When prompted for the Repeaters enter the third and fourth Repeaters in the link.

The illustration shows a Point-to-Point link where a Slave is called through four Repeaters. In this example:

- the Master is calling the Slave, 571-3872, through Repeater 1, 901-1234,
  - then Repeater 2,910-0234,
  - then Repeater 3, 571-3456, and finally
  - Repeater 4, 571-4567.
- Entering the serial number 999-9999 in line 1 instructs the Master to continue calling through the Repeaters programmed on that line.

Entry	Number	Repeater 1	Repeater 2
0	571-3872	901-1234	910-0234
1	999-9999	571-3456	571-4567
2			
3			
4			
5			
6			
7			
8			
9			

Figure 22: Point-to-Point link where a Slave is called through four Repeaters

- To call a Slave radio through one or more Repeaters, that Slave must be called individually.
- With **Call All** selected, the Master will not connect with any Slave radios through Repeaters.
- The Master calls every Slave in the list and connects with the first Slave that responds.
- When calling through a Repeater, the Master must first call that Repeater and establish a communications link with it prior to making contact with the Slave.

8. Advanced Programming

The settings and scenarios covered in this section are considered advanced programming.

8.1. Working with Parallel Repeaters

When Repeaters are added to a network, plan accordingly to avoid creating a parallel Repeater scenario. A parallel Repeater is defined as two or more Repeaters linked to the same point in the network.

8.1.1. Repeaters Data Transmitted on the Same Frequency Key

In this diagram, the Slave radio in the middle has overlapping coverage from both the Repeaters (parallel Repeaters). Data from the Repeaters is transmitted on the same **Frequency Key** in the same time slot, which creates message collisions.

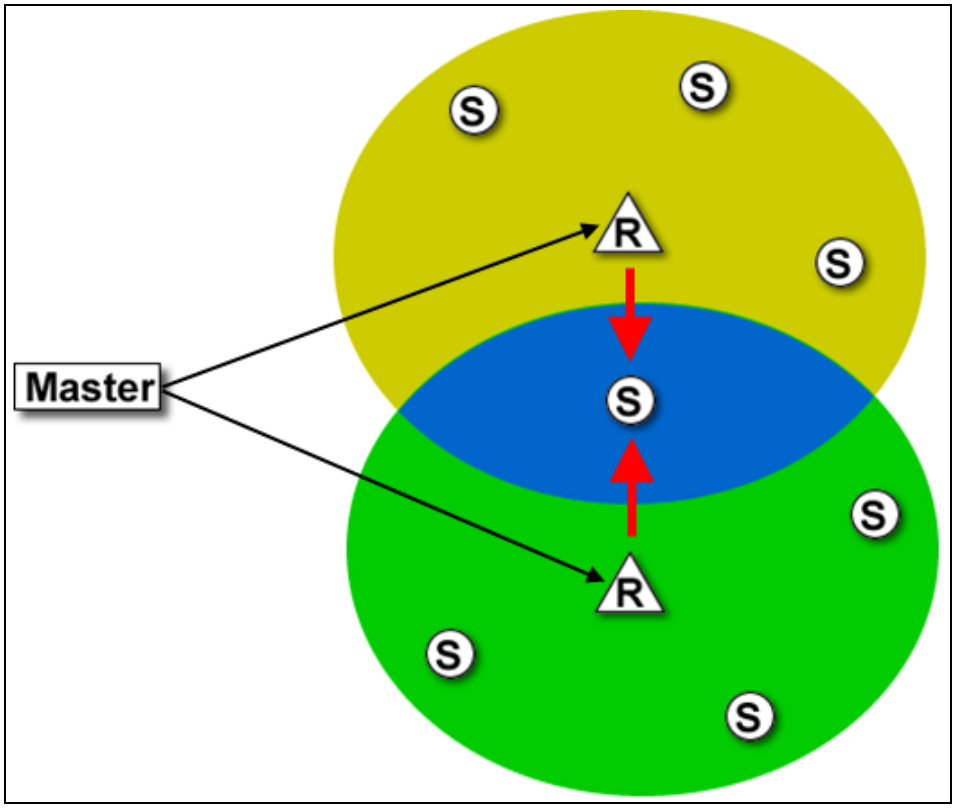


Figure 23: Slave Radio with Overlapping Coverage

To resolve this scenario, change these settings on one or more of the Repeaters in conflict:

Settings to Change on Repeaters in Conflict	
Setting	**Description**
Repeater Frequency	• Set the **Repeater Frequency** parameter in the **MultiPoint Parameters** tab to any number other than **0**. • If set to a number other than **0**, the radio uses the frequency key set in the **Frequency Key** parameter in the **Transmission Characteristics** tab, instead of the frequency key assigned to the Master.
Frequency Key	Set the **Frequency Key** parameter in the **Transmission Characteristics** tab to a key other than that of the conflicting Repeater.

8.1.2. Adding a Repeater to the Network

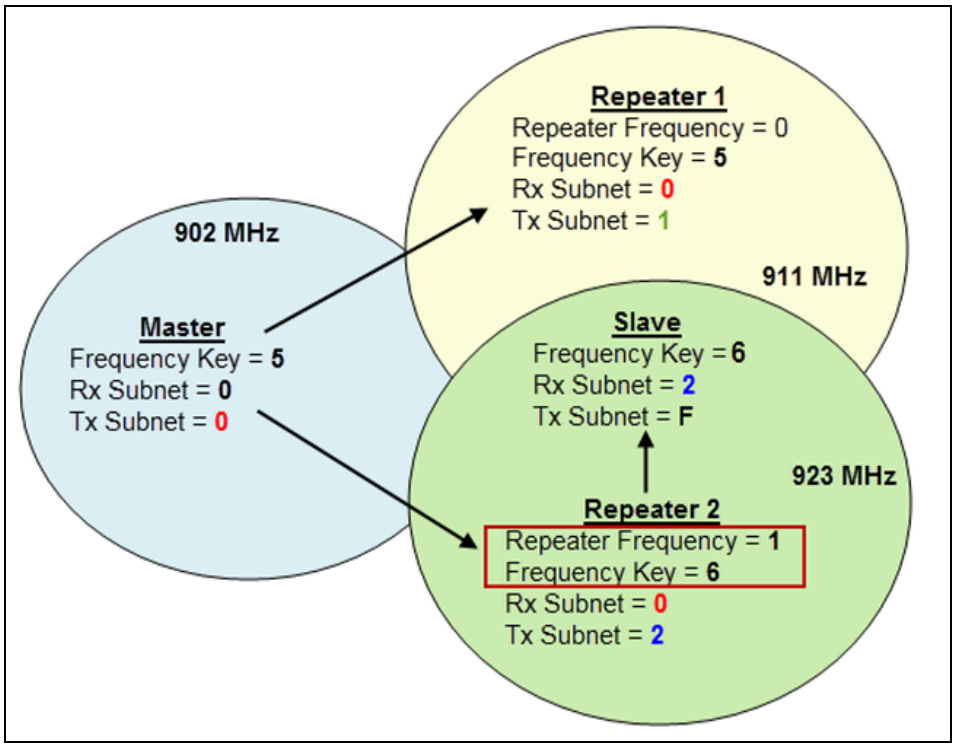


Figure 24: Repeater Added to Network

If a Repeater needs to be added to the network, use these steps to ensure any parallel Repeater issues are resolved before deploying the Repeater in the network.

1. In Tool Suite, run a network diagnostics file.

   Tip: Gather the settings from all the Repeaters that are currently in the network.

2. Review the network diagnostics file.
   Pay special attention to these settings on each Repeater and the Master:
   - Frequency Key
   - Repeater Frequency

- Rx and Tx Subnet IDs

3. On a piece of paper, draw the network.
4. Note the above settings for each Repeater.
   Verify there are no duplicates.
5. If there are duplicates, change the **Repeater Frequency** and the **Frequency Key** parameters described in the table.
6. If the Repeater being adding is the only Repeater in the network, set the:
   a. **Frequency Key** parameter to match the Master.
   b. **Rx Subnet ID** parameter to match the Master's **Tx Subnet ID** parameter setting
   c. **Tx Subnet ID** parameter to `1`.
   d. In the Master, set the **Repeaters** parameter to `Enabled`.

8.2. Setting and Changing Radio Passwords

Use passwords to prevent access to or changing of any of the radio's parameters. This option is useful to prevent unauthorized personnel from gaining access to the radio settings.

Note: If the **Setup Port** option on the **Baud Rate** tab is set to `(1) Main Only` or `(3) Both`, the password is only accepted if the option is accessed from the main data port.
To use the Password function using the diagnostics port, the **Setup Port** option must be set to `(2) Diagnostics Only`.

Warning! If the password feature is enabled and the password is forgotten, the radio MUST be returned to FreeWave to have the password disabled.

8.2.1. Setting the Password

1. On the **Setup** menu in the terminal interface, select `(8) Chg Password`.
   New PW? (<esc> to exit) appears.

   Note: Press <Esc> to cancel the process at any time.

2. Enter **exactly** four characters.
   Passwords are case sensitive.
   <Enter> to accept,<esc> to quit appears.
3. Press <Enter> to accept the password and enable the feature.
   Press <Esc> to quit the process and not enable the password.

Important!: Press <Enter> and the password appears on the line above.
The password is case sensitive and every keystroke is a character.

8.2.2. Changing a Password

After the password feature has been enabled, it is possible to change to a new password.

1. On the **Setup** menu in the terminal interface, select `(8) Chg Password`.
   The **Enter Security Code** prompt appears.

2. Enter the current four-character, case-sensitive password.
   The prompt to enter the new password appears.
3. Re-enter the new four-character, case-sensitive password.

   Note: Press <Esc> to cancel the process at any time.

4. Press <Enter> to accept the password and enable the feature.
   Press <Esc> to quit the process and not enable the password.

Important!: Press <Enter> and the password appears on the line above.
The password is case sensitive and every keystroke is a character.

8.2.3. Disable a Password

After the password features has been enabled, it is possible to disable the password **if the current password is known**.

Important!: The password can only be disabled using the prompt when reading the radio in Tool Suite or through a terminal emulator.
The password CANNOT be disabled using **Setup Terminal** application in Tool Suite.

1. On the **Setup** menu in the terminal interface, select `(8) Chg Password`.
2. Hold down the <Alt> key and type `0255` using the number pad on the keyboard.
3. Release the <Alt> key.
4. Repeat this step three more times (hold <Alt> and type `0255` a total of 4 times).

   Important!: Type the `0255` using the NUM Pad on the keyboard, NOT the top row of numerals.

5. After the fourth entry, the password is disabled.

8.3. Enable and Set Up AES Encryption

Protecting the confidentiality, integrity, and authenticity of data communications is essential to maintaining a robust, reliable, and secure wireless infrastructure. FreeWave has incorporated a number of mechanisms to achieve these critical security objectives, including the use of AES encryption. When available and enabled, AES encryption adds a layer of 128-bit, 192-bit, or 256-bit encryption strength to the data before it is sent over the RF link.

Note: AES encryption is available as an option set at the factory in firmware v10.6.6 and later in some MM2-M13 Serial Radio models.

When using AES encryption, these settings are required:

- Encryption Channel Key (on page 88).
- Encryption Key (on page 89).

- Encryption (Strength) (on page 91).

Important!: These settings are ONLY available in the **(3) Edit Radio Transmission Characteristics > (E) Encryption** menu in the terminal interface.
These settings are NOT available in Tool Suite.

Note: For information about accessing the **Setup** menu using the terminal interface, see Access the Setup Menu Using a Terminal Emulator .

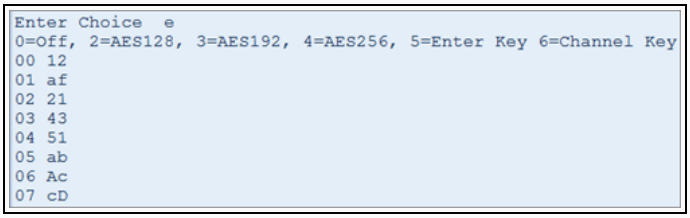
Important!: When AES is enabled, every radio in the network must have matching encryption strengths, encryption keys, and encryption channel keys, and the **MCU Speed** parameter set to 3 for successful communication and data transmission.

8.3.1. Encryption Channel Key

Note: AES encryption settings are available only through the **Setup** menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the **(3) Edit Radio Transmission Characteristics** menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Encryption Channel Key	
Setting	**Description**
Default Setting:	Blank
Options:	Any set of hexadecimal pairs identified in **Description**.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (E) Encryption > (6) Channel Key

Encryption Channel Key	
Setting	**Description**
Description:	The channel key is required when AES encryption is enabled for radios in the network to link when AES encryption is enabled. This setting is different from the **Encryption Key** parameter because it does not encrypt the actual data but is required with the other Golden Settings, described in a network, for the communication to take place. Channel keys should be random and entered as hexadecimal values (e.g., 0 to F in two-character pairs). Any combination of characters can be used for the key. **Example**: A combination of numbers, or a sentence or phrase converted into hexadecimal format. Various string-to-hexadecimal converters are available on the Internet. Enter the encryption key in 2-character hexadecimal combinations in lines 00 to 07 in the lines provided (Figure 25).  **Figure 25: Example of Added 2-character Hexadecimal Combinations**

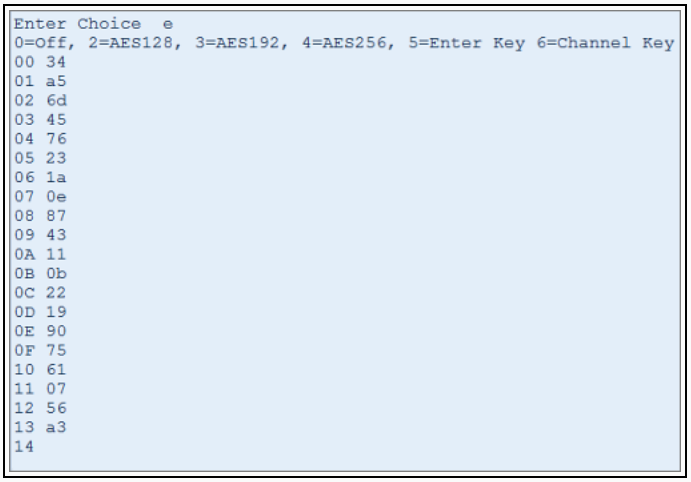
8.3.2. Encryption Key

Note: AES encryption settings are available only through the Setup menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the **(3) Edit Radio Transmission Characteristics** menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Setting	**Description**
Default Setting:	Blank
Options:	Any set of hexadecimal pairs identified in **Description**.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (E) Encryption > (5) Enter Key

Setting	Description

Description:	The encryption key is the piece of information used to encrypt and un-encrypt the data sent through the network. Even with encryption, the data is only as secure as the strength of the encryption key used.
	Keys should be random and entered as hexadecimal values (i.e., 0 to F in two-character pairs). Any combination of characters can be used for the key.
	Example: A combination of numbers, or a sentence or phrase converted into hexadecimal format.
	Various string-to-hexadecimal converters are available on the Internet.
	Enter the encryption key in 2-character hexadecimal combinations in the lines provided (Figure 26):
	 
	Figure 26: Example of Added 2-character Hexadecimal Combinations
	The **Enter Key** option always asks for all 32 lines of the encryption key. However, the encryption strength you select determines how many of the lines are required:
	• **128-bit encryption** - Enter key information in rows 00 to 0F.
	  • The last 16 lines (10 to 1F) are ignored.
	• **192-bit encryption** - Enter key information in rows 00 to 17.
	  • The last 8 entries (18 to 1F) are ignored.
	• **256-bit encryption** - Enter key information in rows 00 to 1F.
	  • All lines are used.

8.3.3. Encryption (Strength)

Note: AES encryption settings are available only through the Setup menu in the terminal interface. If the radio does not have **Encryption** enabled, menu option **E** in the **(3) Edit Radio Transmission Characteristics** menu is blank and has no function.

Important!: This setting MUST match across all radios in the network.

Setting	Description
Default Setting:	(0) Off
Options:	• **(0) Off** - Turns off AES encryption. • **(2) AES 128** - Enables AES encryption, 128-bit strength. • **(3) AES 192** - Enables AES encryption, 192-bit strength. • **(4) AES 256** - Enables AES encryption, 256-bit strength. The options available for selection are based on the encryption strength set at the factory, or within the upgrade to use AES completed with FreeWave technical support's assistance. **Example**: If the radio is factory set to include AES 256, then each strength option is available. However, if the radio is factory set to include AES 192, then only **Off**, **AES 128**, and **AES 192** are available. **Note**: Selecting any option other than 0 enables AES encryption. The encryption key and the channel key are required for successful communication.
Terminal Menu:	(3) Edit Radio Transmission Characteristics > (E) Encryption
Description:	AES encryption is available in various strengths. • The network and the data being sent determine the encryption strength used. • The higher the encryption strength, the stronger the encryption although it can also take longer for the encryption and un-encryption to take place.

8.3.4. Troubleshooting AES Setup

The radios link, transmit data, and then unlink.

- Verify that the **MCU Speed** parameter is set to 3 in the terminal interface.

The radios link, transmit data, but the data is in unrecognizable characters.

- Verify that the **Encryption Key** on each radio is set exactly the same. If the keys do not match, the radios can still transmit data, but cannot decrypt the data.

The radios do not link and the golden settings are all set the same.

- Verify that the **Channel Key** in the Encryption menu is set the same across the radios in the network. If the keys do not match, the radios will not link when AES is enabled, even if the golden settings match.

8.4. Low Baud Rates

The radio's Baud Rate may be set to 300, 600, or 900.

> **Note**: For more information about using a low baud rate, contact FreeWave Technical Support.
> See Contact FreeWave Technical Support (on page 7).

8.5. Multi-Master Synch

The **Multi-Master Sync** setting is reserved for applications in both Point-to-Point and MultiPoint modes with concentrations of Master units where it is necessary to reduce interference between the Master radios.

- For more information about using **Multi-Master Sync** in non-TDMA mode, see Application Note #5412, Synchronizing Collocated Masters (available at http://support.freewave.com/).
  - Registration is required to use this login.

> **Note**: For more information about using **Multi-Master Sync** while in TDMA mode, contact FreeWave Technical Support.
> See Contact FreeWave Technical Support (on page 7).

8.6. Time Divisible Multiple Access (TDMA)

- Available as an optional, add-on feature, the FreeWave Time Division Multiple Access (TDMA) protocol is an enhanced and sophisticated version of Point-to-MultiPoint communications.
- The TDMA protocol provides timing and other parameters, which in turn allow large radio networks to work in a non-polled environment.

> **Important!**: This option is only used for peer-to-peer communications or when applications are very time specific. If you purchase TDMA as an option, additional information is provided to you about implementing and using the feature.

> **Note**: For additional information about TDMA, contact FreeWave Technical Support.
> See Contact FreeWave Technical Support (on page 7).

9. Viewing Radio Statistics

When reading a radio, the system shows data transmission statistics the radio has gathered during the most recent session. This information is valuable to know the signal strength and noise levels of the link. Statistics are gathered during each time the Master and Slave link and are reset when the next link begins.

More data transmission characteristics are available, including averages gathered over time, in the **Network Diagnostics** application.

Use the Radio Transmission Characteristics in the Terminal Interface

1. On the **Setup** menu, select `(4) Show Radio Statistics`.
2. Review these radio statistics:
   - Antenna Reflected Power (on page 94)
   - Noise Level (on page 94)
   - Number of Disconnects (on page 94)
   - Radio Temperature (on page 94)
   - Rate % (on page 95)
   - Transmit Current (mA) (on page 95)
   - Master-Slave Distance (on page 94)
   - Signal (on page 95)

9.1. Antenna Reflected Power

Antenna Reflected Power is a measurement of the transmitted power reflected back into the radio from mismatched antennas and cables, or loose connections between the radio and the antenna.

Use these readings to help decide if corrective action is required:

- 0-5 is good.
- 5-30 is marginal.
- 30+ indicates that you should inspect the radio for loose connections and cable quality.

9.2. Master-Slave Distance

This is the physical distance between the Slave radio and the Master radio in the network.

This distance is most accurate at a distance greater than 2.5 miles (4.0234 km).

9.3. Noise Level

Noise indicates the level of background noise and interference at this radio and at each of the repeaters in the link. The number is an average of the noise level measured at each frequency in the radio's frequency hop table. The individual measurement values at each frequency hop channel are shown in the frequency table. You access the frequency table by pressing **Enter** when the **Radio Statistics** menu is displayed.

Noise levels below 70 J units indicate an acceptable amount of background noise and interference. Additionally, the difference between the average signal level and average noise level should be 30 or more. Noise levels higher than this are an indication of a high level of interference that may degrade the performance of the link. You can mitigate high noise levels by using band pass filters, adjusting the antenna placement, or using antenna polarization.

9.4. Number of Disconnects

Anytime the link between the master and the slave is broken, and the radio loses **Carrier Detect**, it is recorded in the **Number of Disconnects** value. This value indicates the total number of disconnects that occurred from the time the radio is powered on until the radio is put into Setup mode. Under ideal operating conditions, the number of disconnects should be 0. One or more disconnects can indicate any of the following:

- A weak link.
- The presence of severe interference problems.
- The loss of power to any of the radios in the link.

9.5. Radio Temperature

The **Radio Temperature** value is the current operating temperature of the radio in degrees Celsius (C). For proper operation, a FreeWave radio must operate in the temperature range of -40° to +75° C.

9.6. Rate %

The **Rate %** statistic measures the percentage of data packets that the master successfully transmitted to the slave on the first attempt. Use the following as a guide:

- A number of 75 or higher indicates a robust link that provides very good performance even at high data transmission rates.
- A number of 15 or lower indicates a weak or marginal link that provides lower data throughput.

An **Overall Receive Rate** of 100% provides approximately 100 KBaud of bandwidth with an **RF Data Rate** setting of **3**. An **Overall Receive Rate** of 100% provides approximately 150 KBaud of bandwidth with an **RF Data Rate** of **2**. These numbers are reduced approximately 50% if one or more repeaters are in the network.

9.7. Signal

The **Signal** indicates the level of received signal at the radio and at each of the repeaters in the link.

- For each of these, the signal source is the radio that transmits to it.
- The number is an average of the received signal levels measured at each frequency in the radio's frequency hop table.
- The individual measurement values at each frequency hop channel are shown in the frequency table.

You access the frequency table by pressing **Enter** when the **Radio Statistics** menu is displayed. For a reliable link, the margin should be at least 30 J units. You can correct **Low Average Signal Levels** by using higher gain antennas, adjusting antenna placement, and/or using additional repeaters.

Note: Please consult the install manual for antenna and FCC requirements.

9.8. Transmit Current (mA)

This measures the current draw of the transmitter in milliamps.

Note: Refer to radio specs for typical values.

10. Troubleshooting

My radio does not stay in Setup mode and I am not able to program it through the diagnostics port. when I try to place the radio into Setup mode, all three LEDs flash green ( ), and then go back to their previous state.

Additional symptoms of this problem include:

Configuration	Carrier Detect (CD)	Transmit (Tx)	Clear to Send (CTS)
Multipoint Master	Solid red bright	Solid red dim	Off
Multipoint Slave (unlinked)	Solid red bright	Off	Blinking red
Multipoint Slave (linked)	Solid green	Off	Solid red bright
Point-to-Point Master (unlinked)	Solid red bright	Solid red dim	Solid red bright
Point-to-Point Master or Slave	Solid green	Intermittent flash red	Intermittent flash red

Two scenarios could be causing the radio to not enter Setup mode.

The radio is wired for RS485 and Pins 5 and 7 on a board-level radio, or Pins 2 and 3 on an enclosed radio are shorted together.

1. Separate the wires and place the radio into Setup.
2. Change the **Setup Port** parameter in the **Baud Rate tab** to **Diagnostic Only**.

If there is a data source (PLC, RTU, PC, or Terminal Server) connected to the data port data is coming into the data port while you are trying to access Setup through the diagnostics port.

1. Disconnect the data source and place the radio into Setup.
2. Change **Setup Port** parameter in the **Baud Rate tab** to **Diagnostic Only**.

My radios are linked, but I cannot pass data.

Verify that the Baud Rate (on page 30) and Data, Parity (on page 30) settings match between devices.

We recently had a bad storm with lots of lightning and my radio has not worked since. I have replaced the radio but it still does not link.

Verify that the coax cable or antenna were not damaged in the storm.

I have a new network. My radios are linked but I am not able to pass data. Gas Company X has had a FreeWave network out here in the same area for a long time and they are not having issues. What is wrong?

Your network is likely using the default settings for these settings:

- Frequency Key in 1.3GHz Radios (on page 37)
- Network ID (6) (on page 68)
- Max Packet Size (1) and Min Packet Size (2) (on page 43)

Refer to the user manual for the radio you added and change your settings from the default settings.

My network has been running flawlessly for the last 2 years. Now, all of a sudden, I have a group of Slaves that I cannot poll.

A Parallel Repeater has been added or changed in the network and has the same frequency settings and is now interfering with the other Repeater.

Program the new Repeater with a different set of parameters.

My network keeps locking up. If I cycle power on the Master, the network is restored and I can poll again until the next time the network locks up.

There is a "chatty" Slave in the network.

- The Slave is not getting acknowledgment of data it sends to the Master and it keeps trying to resend data to the Master locking out all other communications to the Master.
- This is typically caused by a bad signal from the Slave to the Master.
- Verify line of sight, antenna direction, and noise levels at the Slave.

Most of my sites report in and I can poll, but I cannot poll any of the Slaves that talk back to Repeater 2.

Repeater 2 is experiencing high noise.

I installed a new Slave in my network, but I cannot get it to link. The CD light is solid red and the CTS light is blinking red.

This is a Line of Sight issue or settings issue.

I have a site that used to perform flawlessly. Now I cannot reliably get data from the RTU at this site.

Antenna reflected power is causing a problem.

- Reflected power may be caused by defects or damage in the antenna, cabling, connections, etc.
- Verify that the cabling, connectors, and the antenna are connected correctly and have not sustained any damage.

When I connect directly to my RTU I am able to poll data successfully. When I add in the radios, I cannot get any data from my poll.

Baud rate above 38,400 may need flow control line connected.

10.1. Troubleshooting Flowchart

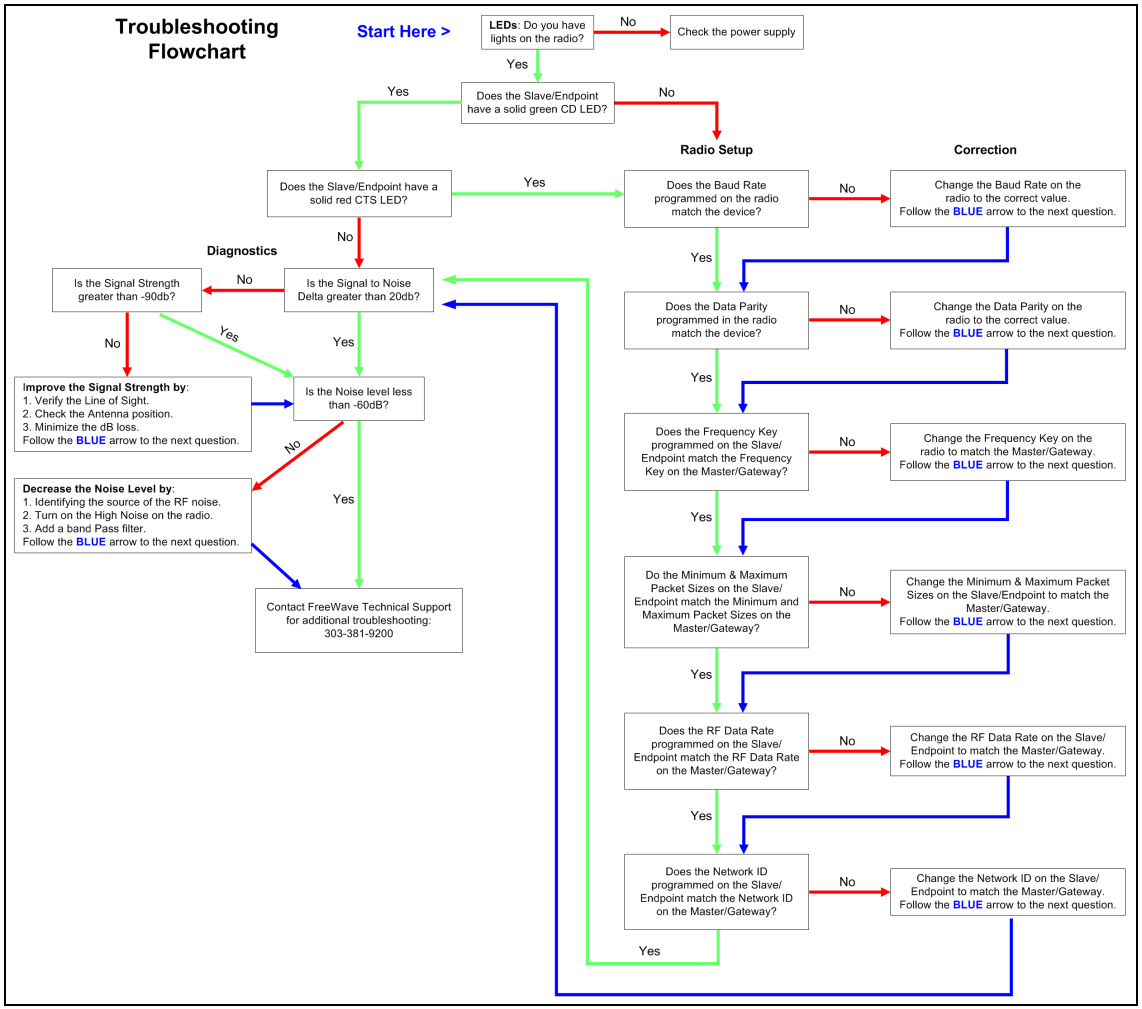


Figure 27: Troubleshooting Flowchart

11. MM2-M13 - Serial Radios Release Notes

These sections describe the updates and known limitations in each software version. The most recent version is listed first.

These Release Notes cover these models:

- MM2-M13-C
- MM2-M13-C-SR
- MM2-M13-LV-C
- MM2-M13-LV-T
- MM2-M13-T
- MM2-M13-T-DEVKIT
- MM2-13X5W

11.1. Version 7.79

Release Date: December 2017

Additions and Changes

- Added AES Encryption for 128-, 192-, and 256-bit encryption.
- **Channel Key** is added to the **Encryption** menu under **Edit Radio Transmission Characteristics**.
  - **Channel Key** is used to customize CRC seeds.

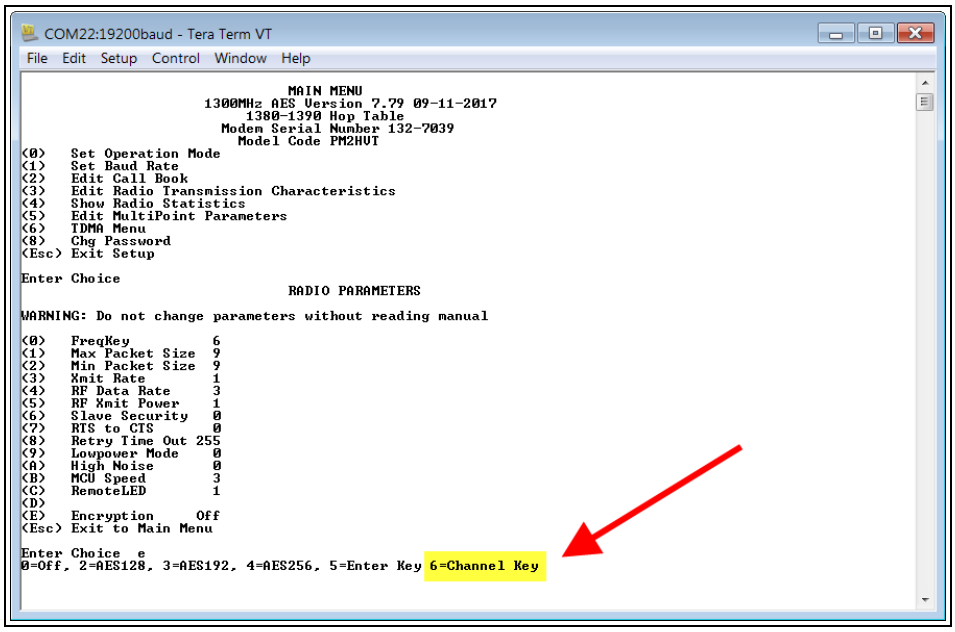


Figure 28: Encryption > Channel Key

Known Limitations and Workarounds

- Transception is possible when different encryption widths are chosen and encryption keys are identical.
  - However, the resulting messages are scrambled.
- The firmware update program is only capable of working with COM ports 1 and 2.
  - Higher COM ports are visible but not functional.
- The **Ethernet Options** menu under the **Set Operation Mode** menu is not functional with the MM2-M13 Serial Radios.
- The **MCU Speed** option in the **Edit Radio Transmission Characteristics** does not prompt the user for options other than 0 (zero) or 1.

> **Important!**: The default **MCU Speed** of 1 is NOT sufficient for encryption functionality.

> **Note**: For **Encryption** to function properly, the **MCU Speed** setting MUST BE **3**.

11.2. Version 7.78

Release Date: March 2017

Additions and Changes

- Changed the menu item from **Enter Hop Freq Offset** to **Enter Hop Freq Offset (0-2)** in menu 3 > 0 > F > 2.

11.3. Version 7.77

Release Date: January 2017

Additions and Changes

- Added use of one of the handshaking signals to control between transmit and receive of the amplifier when in the MM2-M13X5W configuration.

11.4. Version 7.70j

Release Date: January 2010

Additions and Changes

- Added AES encryption.

11.5. Version 7.70i (Initial Release)

Release Date: October 2009

12. Additional Radio Information

This section contains additional important information about the FreeWave radios described in this manual.

- Operational RS232/485 or TTL information.
- Connector pin assignments
- Factory default settings
- Specifications
- Mechanical drawings

12.1. Operational RS422 and RS485 Information

- For RS422, the FreeWave radio can drive 32 standard unit loads and loads the bus with only 1/8 unit load.
- For RS422 and RS485, the FreeWave radio can drive 32 standard unit loads and loads the bus with only 1/8 unit load.
  - A maximum of 256 devices can be tied on the bus if all of the line receivers have 1/8 unit load.
- RS422 is used for 4-wire or full duplex communications with one Master radio and multiple Slave radios.
- The Master radio keeps the line driver asserted at all times.
- The maximum line length is 4,000 feet using two, 120 ohm twisted pair cables with a 5th wire for data common.

An RS485 full duplex using 4 wire plus common is the same as RS422, except the system can have multiple Masters on the bus.

- The most common operation of RS485 is a two-wire comprised of a 120 ohm impedance single twisted pair.
- In this system the loading of the FreeWave radio allows a maximum of 256 1/8 unit load units on the bus.
- Maximum line length is also 4,000 feet with a third wire required for data common.
- The radio checks the line to be certain no other device is transmitting before enabling the line driver for data transmission.

When setting the radio to RS485:

1. Enable Modbus.
2. Set the **Master Packet Repeat** parameter to 3 in the radios that will use RS485.
3. Set the **Turn Off Delay** parameter to 4.

- The **Turn Off Delay** parameter is used to control the length of time the transmitter driver stays asserted after data transmission has finished.
- This is needed to allow the last transmitted character to reach the end of a long line and is normally set to one character length of time.
- This setting also allows three complete reflections to the end of the line to ensure the ringing on the line has fully dampened before releasing the bus to another device.
- Shorter line lengths may use shorter delays, but four ¼-character delay times are recommended.
- In Modbus, a **Turn Off Delay** -parameter setting of 0causes internal timing errors.

Important!: No provision for handshaking is made in any of these modes of operation.
Data rates of 57.6 KBaud and above are **not recommended** without a protocol that can handle error detection properly.

12.1.1. RS485 Half Duplex Pin-Outs

Function	Bare Board Pin Number	DB-9 Pin Number / 12-pin Waterproof Connector
Wire to both pins for Bus +	Short 5 and 7	Short 2 and 3
Wire to both pins for Bus -	Short 9 and 10	Short 7 and 8
Signal Ground	4 or 6	5

12.2. RS232 Pin Assignments (DB-9)

RS232 Pin Assignments (DB-9)			
Pin	**Assignment**	**Signal**	**Description**
1	CD - Carrier Detect	Output	Used to show an RF connection between radios.
2	TX - Transmit Data	Output	Used to transmit data bits serially from the radios to the system device.

RS232 Pin Assignments (DB-9)			
Pin	**Assignment**	**Signal**	**Description**
3	RX - Receive Data	Input	Used to receive data bits serially from the system device connected to the radios.
4	DTR - Data Terminal Ready	Input	Used only in radios in Point-to-Point Slave/Master switchable mode or for DTR Connect.
5	GND - Ground		Signal return for all signal lines shared with Pin 9.
6	DSR - Data Set Ready	Output	Always high when the radio is powered from the 2.5 mm power connector. Indicates power is on to the radio. Also, this pin can be used for +12.0 Volts when powering the radios directly through the RS232 port. **Important!**: This is not used on the OEM module.
7	RTS - Request to Send	Input	The radio does not recognize RTS for flow control. RTS is used as a control line in RTS/CTS mode.
8	CTS - Clear to Send	Output	This signal is used to tell the system device connected to the radio that the radio is ready to receive data. • When asserted, the radio accepts data, when de-asserted the radio does not accept data. • This should always be used for data rates above 38.4 KB or a risk of lost data may occur if an RF link is not very robust.
9	GND - Ground		Signal return for all signal lines shared with Pin 5.

12.3. Board Level Pinout

- J1 - 14 pin, 2.00mm centers, Samtec TMM series, TMM-107-01-G-D-SM-options
- Mates with Samtec CLT, SMM, MMS, SQT, ESQT, SQW, TLE, TCSD, TLSD series

Board Level Pinout			
Pin	**Assignment**	**Signal**	**Description**
1	Power	Input	MM2-M13-LV-T: 5.0 V DC MM2-M13-LV-C: 5.0 V DC MM2-M13-C: 8 – 30 V DC MM2-M13-T: 8 – 30 V DC
2	Interrupt / Reset	Input	Active Low, 100µs pulse
3	DTR - Data Terminal Ready	Input	0 – 3.5 V TTL[1], [2], RS-232/485[3]
4	GND - Ground		
5	TX - Transmit Data	Output	0 – 3.5 V TTL[2], RS-232/485[3]

Board Level Pinout			
Pin	**Assignment**	**Signal**	**Description**
6	RSSI Out	Output	Analog out, 0 – 3.5 V
7	RX - Receive Data	Input	0 – 3.5 V TTL[1], [2], RS-232/485[3]
8	CD - Carrier Detect	Output	0 – 3.5 V TTL[2], RS-232/485[3]
9	RTS - Request to Send	Input	0 – 3.5 V TTL[1], [2], RS-232/485[3]
10	CTS - Clear to Send	Output	0 – 3.5 V TTL[2], RS-232/485[3]
11	Diag Received (RX) Data	Input	RS-232
12	Diag Transmitted (TX) Data	Output	RS-232
13	GND - Ground		
14	Baud Clock	Output	

[1] – 330 Ω resistor in series.

[2] – Model #MM2-M13-T and MM2-M13-LV-T

[3] – Model #MM2-M13-C and MM2-M13-LV-C

Note: See Figure 29 for identification of pin numbers.

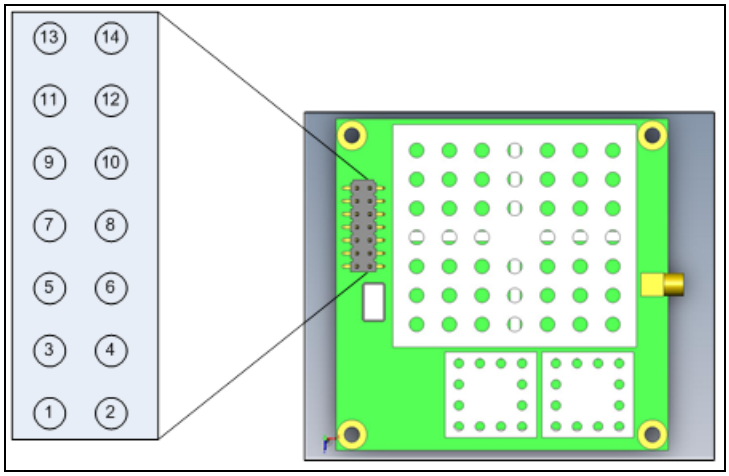


Figure 29: Board Level Pinout Assignment

12.4. MM2-M13 Serial Radio Pinout

MM2-M13 Serial Radio Pinout	
Pin	**Identification**
1	B+ (See above)
2	Interrupt / Reset

MM2-M13 Serial Radio Pinout	
Pin	**Identification**
3	DTR - Data Terminal Ready
4	GND - Ground
5	TX - Transmit Data
6	RSSI Out
7	RX - Receive Data
8	CD - Carrier Detect
9	RTS - Request to Send
10	CTS - Clear to Send
11	Diag Received (RX) Data
12	Diag Transmitted (TX) Data
13	GND - Ground
14	Baud Clock

Appendix A: Technical Specifications

MM2-M13 Technical Specifications	
Transmitter	
Frequency Range	1.350 to 1.390 MHz
RF Data Rate	153 kbps or 115 kbps, user selectable
Output Power	Up to 1 W
Data Link Range	40 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Channels	1 to 112 (out of 172), user selectable
Hopping Bands	7, user selectable
Hopping Patterns	15 per band, 105 total, user selectable
RF Connector	MMCX or SSMC
Receiver	
Sensitivity	-106 dBm @ 115.2 kbps for BER 10^{-4} -104 dBm @ 153.6 kbps for BER 10^{-4}
IF Selectivity	-20 dB at fc ± 230 kHz
System Gain	136 dB
Data Transmission	
Error Detection	32-bit CRC, retransmit on error
Data Throughput	115.2 kbps

MM2-M13 Technical Specifications	
Data Encryption	FHSS Technology
Protocol	RS232 / RS485 or TTL
Options	AES 128 / 192 / 256-bit encryption TDMA Super Epoch TDMA
Interfaces	
Data Interface	Serial
Interface Connector	Dual Row 14-pin Header, 2mm pin spacing
Power Requirements	
Operating Voltage	+5 VDC (LV models only) +8.0 to +30.0 VDC

Mode	+5 VDC (LV models only)	+12 VDC	+30 VDC
Transmit	1000 mA	500 mA	200 mA
Receive	120 mA	75 mA	40 mA
Idle	30 mA	20 mA	9 mA
Sleep	8 mA	5 mA	2 mA

Operating Environment	
Operating Temperature	-40°C- +75°C
Humidity	0 to 95%, non-condensing
Enclosure	Board level
Dimensions	2 L x 2 W x 0.3 H (in) 50.8 L x 50.8 W 7.6 H (mm)
Weight	0.74 oz 21 g

* At 100% receive success rate. RF data rate setting of 2.

Appendix B: MM2-M13-C and -LV-C Mechanical Drawing

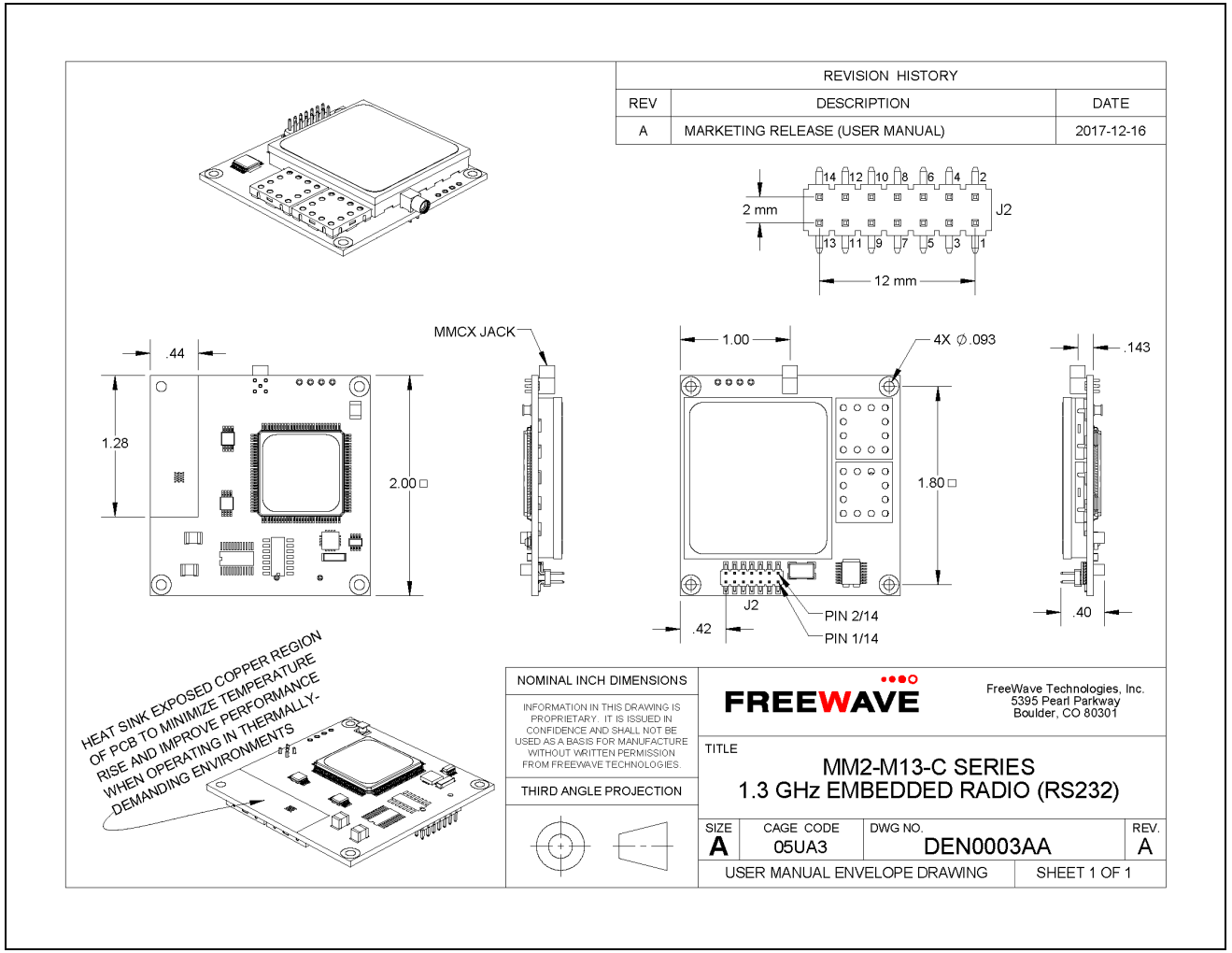


Figure 30: MM2-M13-C and -LV-C Mechanical Drawing

Appendix C: MM2-M13-T and -LV-T Mechanical Drawing

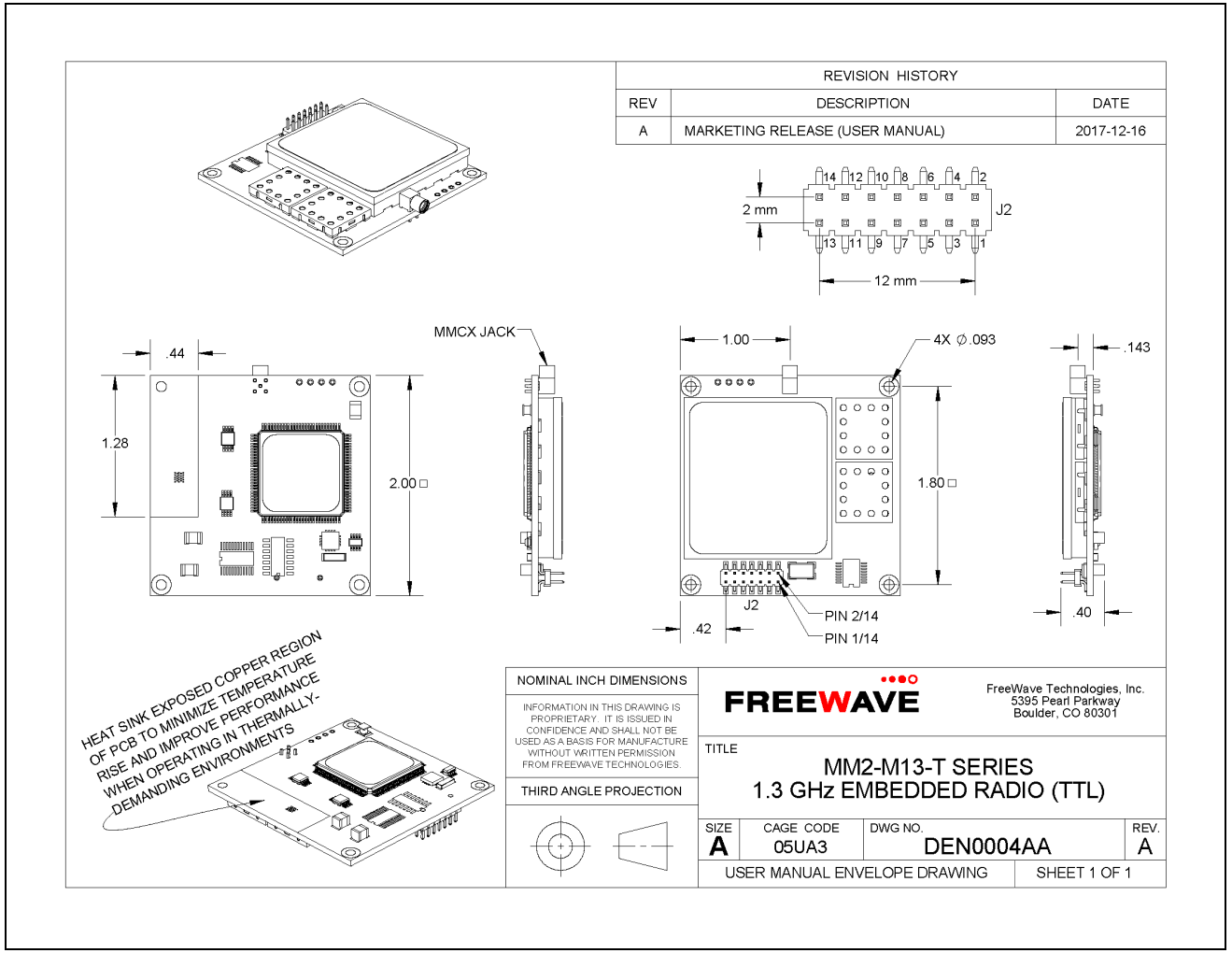


Figure 31: MM2-M13-T and -LV-T Mechanical Drawing

Appendix D: Factory Default Settings

The MM2-M13 Serial Radio is shipped from the factory with these Default Settings:

Factory Default Settings: MM2-M13 Serial Radio	
Setting	**Default**
Operation Mode	
Point to Point Master	0
Set Baud Rate	
Baud Rate	19200
(A) Data, Parity	0
(B) Modbus RTU	0
(C) RS232 / RS485	0
(D) Setup Port	3
(E) TurnOffDelay / TurnOnDelay	0/0
(F) Flow Control	0
Radio Parameters	
(0) FREQ KEY	5
(0) HOP TABLE VERSION	0
(1) HOP TABLE SIZE	112
(2) HOP FREQ OFFSET	0
(3) Frequency Zone	All 1's (Enabled)
(4) Single Freq	131

Factory Default Settings: MM2-M13 Serial Radio	
Setting	**Default**
(1) MAX PACKET SIZE	8
(2) MIN PACKET SIZE	9
(3) XMT RATE	1
(4) RF DATA RATE	2
(5) RF XMT POWER	10
(6) SLAVE SECURITY	1
(7) RTS TO CTS	0
(8) RETRY TIMEOUT	255
(9) LOW POWER MODE	0
(A) High Noise	0
(B) MCU Speed	1
(C) Remote LED	0
Multipoint Parameters	
(0) NUMBER OF REPEATERS	1
(1) MASTER PACKET REPEAT	0
(2) MAX SLAVE RETRY	9
(3) RETRY ODDS	0
(4) DTR CONNECT	0
(5) REPEATER FREQUENCY	0
(6) NETWORK ID	255
(7) RESERVED	-
(8) MULTI MASTER SYNC	0
(9) 1 PPS ENABLE DELAY	255
(A) SLAVE/REPEATER	0
(B) DIAGNOSTICS	0
(C) SUBNET ID	Disabled
Rx ID	F
Tx ID	F
(D) RADIO ID	Not Set
(E) Local Mode	0
(G) Radio Name	blank

Appendix E: Single Frequency Setting

Use this **Single Frequency Setting** table to determine the frequencies per setting.

Single Freq Setting	Frequency (MHz)	Single Freq Setting	Frequency (MHz)
76	1350.1440	163	1370.1888
77	1350.3744	164	1370.4192
78	1350.6048	165	1370.6496
79	1350.8352	166	1370.8800
80	1351.0656	167	1371.1104
81	1351.2960	168	1371.3408
82	1351.5264	169	1371.5712
83	1351.7568	170	1371.8016
84	1351.9872	171	1372.0320
85	1352.2176	172	1372.2624
86	1352.4480	173	1372.4928
87	1352.6784	174	1372.7232
88	1352.9088	175	1372.9536
89	1353.1392	176	1373.1840
90	1353.3696	177	1373.4144
91	1353.6000	178	1373.6448
92	1353.8304	179	1373.8752
93	1354.0608	180	1374.1056

Single Freq Setting	Frequency (MHz)	Single Freq Setting	Frequency (MHz)
94	1354.2912	181	1374.3360
95	1354.5216	182	1374.5664
96	1354.7520	183	1374.7968
97	1354.9824	184	1375.0272
98	1355.2128	185	1375.2576
99	1355.4432	186	1375.4880
100	1355.6736	187	1375.7184
101	1355.9040	188	1375.9488
102	1356.1344	189	1376.1792
103	1356.3648	190	1376.4096
104	1356.5952	191	1376.6400
105	1356.8256	192	1376.8704
106	1357.0560	193	1377.1008
107	1357.2864	194	1377.3312
108	1357.5168	195	1377.5616
109	1357.7472	196	1377.7920
110	1357.9776	197	1378.0224
111	1358.2080	198	1378.2528
112	1358.4384	199	1378.4832
113	1358.6688	200	1378.7136
114	1358.8992	201	1378.9440
115	1359.1296	202	1379.1744
116	1359.3600	203	1379.4048
117	1359.5904	204	1379.6352
118	1359.8208	205	1379.8656
119	1360.0512	206	1380.0960
120	1360.2816	207	1380.3264
121	1360.5120	208	1380.5568
122	1360.7424	209	1380.7872
123	1360.9728	210	1381.0176
124	1361.2032	211	1381.2480
125	1361.4336	212	1381.4784
126	1361.6640	213	1381.7088
127	1361.8944	214	1381.9392

Single Freq Setting	Frequency (MHz)	Single Freq Setting	Frequency (MHz)
128	1362.1248	215	1382.1696
129	1362.3552	216	1382.4000
130	1362.5856	217	1382.6304
131	1362.8160	218	1382.8608
132	1363.0464	219	1383.0912
133	1363.2768	220	1383.3216
134	1363.5072	221	1383.5520
135	1363.7376	222	1383.7824
136	1363.9680	223	1384.0128
137	1364.1984	224	1384.2432
138	1364.4288	225	1384.4736
139	1364.6592	226	1384.7040
140	1364.8896	227	1384.9344
141	1365.1200	228	1385.1648
142	1365.3504	229	1385.3952
143	1365.5808	230	1385.6256
144	1365.8112	231	1385.8560
145	1366.0416	232	1386.0864
146	1366.2720	233	1386.3168
147	1366.5024	234	1386.5472
148	1366.7328	235	1386.7776
149	1366.9632	236	1387.0080
150	1367.1936	237	1387.2384
151	1367.4240	238	1387.4688
152	1367.6544	239	1387.6992
153	1367.8848	240	1387.9296
154	1368.1152	241	1388.1600
155	1368.3456	242	1388.3904
156	1368.5760	243	1388.6208
157	1368.8064	244	1388.8512
158	1369.0368	245	1389.0816
159	1369.2672	246	1389.3120
160	1369.4976	247	1389.5424
161	1369.7280	248	1389.7728
162	1369.9584		

Appendix F: FreeWave Legal Information

Export Notification

FreeWave Technologies, Inc. products may be subject to control by the Export Administration Regulations (EAR) and/or the International Traffic in Arms Regulations (ITAR). Export, re-export, or transfer of these products without required authorization from the U.S. Department of Commerce, Bureau of Industry and Security, or the U.S. Department of State, Directorate of Defense Trade Controls, as applicable, is prohibited. Any party exporting, re-exporting, or transferring FreeWave products is responsible for obtaining all necessary U.S. government authorizations required to ensure compliance with these and other applicable U.S. laws. Consult with your legal counsel for further guidance.

Aviso IFETEL

La operación de este equipo está sujeta a las siguientes dos condiciones: (1) es posible que este equipo o dispositivo no cause interferencia perjudicial y (2) este equipo o dispositivo debe aceptar cualquier interferencia, incluyendo la que pueda causar su operación no deseada.

IC Notifications

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Ce dispositif est conforme aux normes permis-exemptes du Canada RSS d'industrie. L'opération est sujette aux deux conditions suivantes: (1) ce dispositif peut ne pas causer l'interférence, et (2) ce dispositif doit accepter n'importe quelle interférence, y compris l'interférence qui peut causer le fonctionnement peu désiré du dispositif.

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Warning! Explosion Hazard- Substitution of components may impair suitability for Class 1, Division 2. **DO NOT REMOVE** or insert the diagnostics cable while the circuit is live.

UL Power Source

Input power shall be derived from a certified, Class 2:

- single power source or
- a limited power source (LPS) in accordance with:
  - IEC/EN 60950-1
  - CAN/CSA C22.2 No. 60950-1-07.

Do not connect or disconnect any connectors while the circuit is live unless the area is known to be non-hazardous.

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